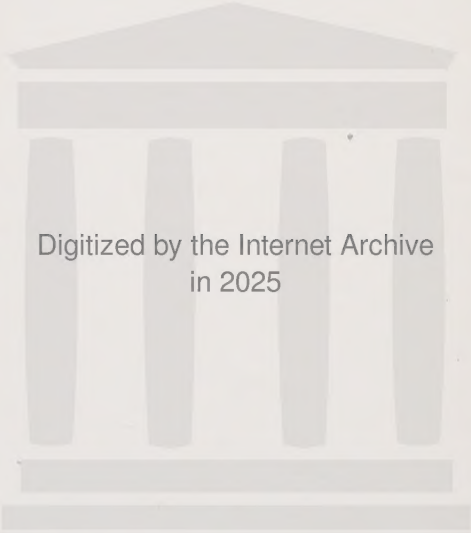
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ESTIMATING BUILDING COSTS

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ESTIMATING BUILDING COSTS

BY

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Member of the American Society of Civil Engineers, Member of the American Society of Mechanical Engineers, Member of the New Jersey Society of Architects

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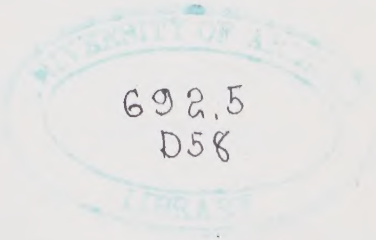

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CHARLES F. DINGMAN

PALMER, MASS.,
June, 1923.

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ESTIMATING BUILDING COSTS

CHAPTER I

INTRODUCTION

The present volume is the result of about fifteen years' consideration as to the best method of presenting, to the ambitious young men in the building profession, the rudiments of the knowledge required to become competent estimators.

No single book can make a competent estimator of any man, and no claim is made that this book will accomplish that result, but a diligent study of the methods laid down and the principles expounded will develop the necessary habits of thought which, combined with practical experience and keen observation, will enable the student to become such an estimator.

The successful estimator is essentially a visualizer; he must be able to take a set of plans and specifications, with the quantity survey, and mentally see the several parts of the building put together. If he cannot do that, all the data available are not always sufficient to keep him from making an estimate that is far too low or far too high.

It is not intended that this book shall be primarily a "data-book," though it necessarily contains a great deal of estimating data, much of it presented in tabular form. Nor is it intended that this book shall replace or supersede any of the many excellent reference books and hand-books that have been published for estimators' use.

Those books are essentially data-books and are intende for use only by men who already possess a competer knowledge of estimating principles or who, in the capacit of appraisers or adjusters, want to arrive at figures ver quickly.

This volume is intended for the less experienced ma to train him to analyze every construction job into i component parts, to apply his cost data, adjusted to exis ing conditions, to the several necessary operations and thu to calculate a price that will approach the actual cost doing the work as closely as is humanly possible.

Naturally, in a work of this size, the treatment is n exhaustive, since entire volumes have been published o the subjects of earth and rock excavation alone, and a sim lar volume has been published on concrete work. Bric work and carpenter work could well fill equally large vo umes.

However, each subject has been treated at sufficie length to enable the reader to get a clear insight into t factors involved, their relative importance, and the metho to be employed in estimating their cost.

There are two general methods employed in prepari an estimate; one method is to summarize all of the cos involved in a unit quantity of the item under consideratio then to multiply the figures thus derived by the number units. The other method is to calculate the total quan ties of materials and labor needed to complete the operati and, multiply by their individual costs, determine t total estimated cost of the operation.

The first method has the advantage of presenting t information in a form that makes it possible readily adjust the estimate for reductions or increases in quantiti if any are made. It is probably the handiest method f use by an experienced estimator whose training is su that he will be certain to include all the accessory co in his unit prices.

For the student, the second method seems better a is used throughout the text, but it is well to form t

abit of resolving all totals back to unit prices, as this fords an opportunity for a mental check on your work, a eans of comparison with other estimates and a method of llowing the trend of costs in each department of work. Such subjects as Plumbing, Heating, Electrical Wiring, Iechanical Equipment of Buildings, and other specialties ave not been included at all because it is not considered safe practice for a builder to attempt to estimate those ems himself. Sub-bids should always be secured from pecialists in those lines and they will be competent to eval- ate properly all specification requirements, as well as cur- ent market and labor conditions. No matter how com- etent a building estimator may be in his own field, it is ot reasonable to expect him to have an intimate knowledge f the business of all of the specialists with whom he will ave to deal.

It will be noted, in working out many of the examples the text, that fractional quantities have been increased full quantities and fractional hours to full hours. The resent status of refinement in the methods of handling aterials and administering labor on construction work is ot such as to warrant too great a refinement in estimating ethods and the percentage of error thus introduced is not fficiently large to affect the results of bidding.

Price lists have not been included in the text because it deemed essential that the estimator in active practice ould always obtain the current prices on all materials rectly from his sources of supply and he will thereby iminate a very important source of error.

For instance, it might be very interesting to an estimator have a price list of the various sizes of steel sash, to- ether with information as to the manufacturers' methods pricing.

But prices change and local conditions affect sales poli- es, while there is seldom an occasion that does not allow me for obtaining prices direct from manufacturers or ealers, so there is no practical advantage in having the rice list

One thing this book attempts to accomplish, that is to induce estimators to pay more attention to the method of obtaining and recording data on the basis of production per man-hour rather than on that of the money cost per unit.

The possible production per man-hour is a reasonably constant quantity but money costs vary with every market change and, unless every condition is properly recorded, money costs reported for one operation may not be of any use in estimating the cost of a similar operation performed under different circumstances.

CHAPTER II

EXCAVATING, GRADING, BRACING

SECTION I. EXCAVATION BY HAND

Because of the apparent simplicity of the operation of excavating in most building construction, it is not usual to give as much consideration to estimating the cost as the importance of this item would warrant.

There are so many factors which affect the cost of excavation that it is really one of the most difficult parts of building work to estimate accurately.

Computing the quantity of material to be excavated is a comparatively simple matter, but consideration must be given to all of the following factors:

Care must be taken to include the dimension from outside to outside of the spread of footings and also from the top of the grade to the underside of the cellar floor construction. Footing trenches, pier-holes and other excavations extending below the general cellar excavation should be figured separately, under proper headings, and individual prices computed for each class of excavation.

When the nature of the soil is such that the banks will not retain their vertical position without support, proper allowance must be made for bracing. With shallow excavations, or where building lines or other constructions do not interfere, it will usually be found cheaper to slope the banks than to brace them. A discussion of the cost of bracing will be given further on.

If the banks are to be sloped it will be necessary to figure the cost of excavating a prism of earth all around the excavation, the dimensions of this prism being deter-

mined by the depth of the excavation and the angle
repose of the material to be excavated. The volume
this prism will also have to be added to the quanti
of backfilling.

The angle of repose, or the slope which the materi
will maintain without further sliding, is approximately
follows:

TABLE I.—ANGLES OF REPOSE

(Re-tabulated from Information given in the "Handbook
Building Construction," by Hool and Johnson. McGraw-Hill Bo
Co., New York.)

Material	Angle Dry	Degrees from Horizontal	
		Moist	Wet
Sand	20–35	30–45	20–4
Earth	20–45	25–45	25–3
Gravel	30–48		
Gravel, sand and clay	20–37		

Variations in Soils.—These figures are, of course, subj
to as wide a variation as there are variations in the s
formation at different places. Determination of the an
for any particular kind of earth can only be made by obs
vation, and the estimator should make it his business
be sufficiently conversant with the soils in his vicinity
approximate the angle of repose in any instance, or
should get that information from some one who is famil
with local conditions.

In fairly firm soils, footing and pier excavations can
figured as the net width of the bottom course (provided

chitect or engineer will permit the work to be executed at way), without allowance for forms, but sufficient space ust be allowed for footing forms in unstable soils and wall or pier forms in all cases where they will be ed. This allowance is usually taken as one foot from e face of the wall.

Where the area to be excavated is comparatively small d the depth of the cut is not over nine or ten feet, the ovelling will usually be done entirely by hand and the ures in Table II represent the amount of earth that n be loosened and shovelled out per man hour.

In very shallow footing trenches the production will ry but slightly from the figures in the first two columns t for deeper trenches and for deep and narrow pier s the production will be reduced, as indicated in the rd and fourth columns.

TABLE II.—EXCAVATING

oduction per Man per Hour in Cubic Yards, Including Loosening with Pick and Shovelling into Carts.

Material	General Work		Trenches	Pier Pits
	Dry	Wet		
nd or loam	1.12	0.70	.54	.51
dinary medium soil	0.70	0.40	.31	.29
avy soil or clay	0.45	0.30	.24	.23
rd-pan	0.40	0.25	.20	.19

Table II is to be used in cases where the material is be thrown into carts or out onto banks not over 6 feet h.

For greater heights than 6 feet it will be necessary t throw the spoil out in two or more "lifts" or to handle i mechanically. Of course, where it is practicable to run th carts down into the excavation, the material can alway be shovelled directly from the floor of the cut into th carts as usual.

Where spoil is handled manually by one or more "lifts it is necessary to figure the cost of a scaffold or platform from which the second or subsequent "lifts" are to be mad and the labor of shovelling will be calculated for each lif on the basis of the figures in Table III.

The cost of erecting scaffolds will be taken up in Chapte III, in connection with Brickwork.

TABLE III.—SHOVELLING EXCAVATED MATERIAL

Production per Man-Hour, Material Previously Loosened by Plowing or Other Means.

	Cubic Yards
Ordinary medium soil	1.22
Sand or loam	1.25
Heavy soil or clay	0.95
Hard-pan	0.85

SECTION II. PLOWING AND SCRAPING

Where the area to be excavated is sufficiently large t permit the horses to be operated efficiently, it will ofte be found economical to use a plow to break up the so and prepare it for the shovellers, thus practically obviatin the need for picking for as much of the depth as is plowe

The figures in Table III are to be used for estimatin the cost of shovelling out after plowing.

When scrapers are to be used, except for such loo

material as sand or gravel, it is almost always necessary to loosen up the soil before scraping.

The quantities of earth that can be loosened up by one plow, drawn by two horses and handled by a driver and a helper, are as follows:

TABLE IV.—PLOWING

Production in Cubic Yards per Hour

	Cubic Yards
Top soil	40
Ordinary medium soil	35
Heavy soil	35
Soft clay	20
*Stiff clay	20

*In plowing stiff clay, four horses will be needed.

Comparatively shallow excavations in sand, gravel or loose soil can often be handled very economically by means of scrapers, particularly if the excavated material may be disposed of within a very short distance.

The maximum distance for economical use of ordinary drag-scrapers is 200 feet, and for wheel-scrapers it is 500 feet.

Since the drag-scraper will carry 4 cubic feet of material (the nominal capacity is 5 cubic feet) and the team will average a speed of 2 miles per hour or 176 feet per minute, it follows that the time cost of moving a cubic yard of earth a distance of 200 feet, allowing 25 feet at each end for turning and ½ minute per trip for loading and dumping the scraper, will be as follows:

$$27 \div 4 = 6.75 \text{ trips per cubic yard}$$

$$225 \div 176 = 1.28 \text{ minutes per trip each way, or}$$

2.56 minutes per round trip, plus ½ minute for loading and dumping, equals a total of 3.06 minutes per trip; therefore, 6.75 trips at 3.06 minutes equals 20.65 minutes of team time per cubic yard. Allowing for unforeseen delays this should be figured as 23 minutes per cubic yard.

In addition to the time of the teams and drivers, it is necessary to have at least one man to load the scrapers. He can handle about 150 scrapers per hour, which means that a sufficient number of scrapers should be employed to have them load on 24 seconds headway. Where a less number of scrapers is in use the helper's time will be distributed over their work at a proportionately greater cost per cubic yard.

Wheel-scraper work may be figured by the same method, in each case the actual capacity should be taken as 80 per cent of the rated capacity, and the cost of a "snatch" team should be included when the rated capacity of the scraper exceeds 14 cubic feet or where the incline is steep.

When the earth is loosened by the plow to prepare for scrapers, the cost of plowing will, of course, be the same as when preparing for hand shovelling.

SECTION III. MOVING EARTH

The earth shovelled out will, of course, have to be moved away by barrows, carts, motor trucks, cable-way or other means. Since the first three are the most usual for building construction, they are the only ones that will be considered in detail here.

The general building contractor should, as a rule, seek either unit or lump-sum sub-bids from excavating contractors when the work to be done is unusually complicated but the matter contained in this chapter will be ample to enable him to estimate on any ordinary piece of work.

Wheelbarrows are not usually economical except for moving over very short distances, and the amount which one man can transport per 100 feet per hour is as follows:

TABLE V.—WHEELING

Cubic Yards of Earth Moved 100 Linear Feet by One Man per Hour

	Dry	Wet
Sand or loam	1.8	1.6
Ordinary medium soil	1.7	1.4
Heavy soil or clay	1.5	1.2
Hard-pan	1.4	1.1

A two-horse cart, having a capacity of 1.50 cubic yards of loose material, which equals about 1.20 cubic yards measured before excavating, can travel at the rate of about 2 miles per hour when loaded and 3 miles per hour returning; 5 minutes must be allowed on each trip for dumping and turning and 10 minutes for loading. This quantity is for fairly good roads; if the roads to be traversed are poor, the quantity hauled will be reduced in proportion.

Where the grade of the ramp out of the excavation is very steep it will be necessary to keep a helper or "snatch" team of horses, with driver, on hand to assist the other teams. The cost of this additional team and driver will be distributed over the production of the other teams and will become less per cubic yard as the production of the other teams increase.

In most instances it will be necessary to keep a man at the dump to spread the excavated material as it arrives. He can usually spread about 10 cubic yards per hour. If material is delivered at a more rapid rate than that, an additional man will be required. In other instances no provision will need to be made for spreading at the dump, but this should always be investigated and considered when making an estimate.

SECTION IV. BACKFILLING

In practically every building operation it will be necessary to back-fill and tamp the spaces between the banks and the construction. When the earth to be back-filled is available alongside the trench, the cost may be figured on the following basis:

TABLE VI.—BACKFILLING

Cubic Yards per Man-hour

	Cubic Yards
Sand or loam	2½
Ordinary medium soil	2
Heavy soil or clay	1½

When it is necessary to wheel the earth from a pile away from the trench, the cost of such wheeling must be figured as previously explained.

SECTION V. POWER EXCAVATION

It is hardly within the scope of a book of this size to even attempt to cover adequately such a broad subject as Power Excavation. It occupies a large portion of the contents of such books as Gillette's "Handbook of Construction Cost" (McGraw-Hill Book Co., New York), and with its kindred subject, Rock Excavation, furnishes sufficient material for two other rather large books by the same author.

For very large and fairly deep excavations a steam shovel should show an appreciable saving over any other method of excavation. However, most building contractors do not make a practice of owning their own steam shovels, but will sub-let such work to an excavating contractor at a lump sum or unit price.

Capacities of different shovels of the same nominal rating

will vary appreciably and the estimator should be familiar with the performance of the machine which he proposes for any particular work.

If constantly employed in digging, the following production could be obtained from the various sized shovels:

TABLE VII—STEAM SHOVEL WORK

(In Ordinary Medium Soil)

Size of Shovel (Cubic Yards)	Capacity per Minute (Cubic Yards)
¾	2.25
1¼	3.75
1½	4.50
1¾	5.25
2	6.00

But, since a great portion of the time of the shovel will be used in moving, it is not wise to figure upon an actual production of more than one-half of the amounts just given.

The cost of disposing of the material will be the same as for hand excavation, except that the loading time will be greatly decreased, one minute being about the maximum if the work is arranged properly.

SECTION VI. PREPARING AN ESTIMATE

No allowance has been made for foreman, superintendent, timekeeper, etc., in any of the figures thus far. The general building contractor will find it most practicable to estimate the total time required for the entire building and to calculate the cost of salaries for superintendent and timekeeper on that basis.

The time of foreman must, however, be included in the cost of excavating and, as one foreman can usually handle any ordinary sized operation, the procedure for calculating

the unit cost of excavating for a typical building will be as follows:

It is assumed that the soil is dry clay, that the banks will stand without bracing, that shoveling will be done by hand and the material disposed of in a dump a mile away over fairly good roads.

Plowing:

Cost of team, plow and driver..... $1.00 per hour
Cost o` helper..... .35 per hour

$1.35

$\frac{\$1.35}{20 \text{ cu. yds.}}$ = per cubic yard..... $ .0675

Shoveling:

Cost of labor,—$.35 per hour,

$\frac{.35}{1.22 \text{ cubic yards}}$ = per cubic yard..... $ .2869

Hauling:

Cost of team, cart and driver, $1.00 per hour
Loading time..... 10 minutes
Dumping time..... 5 minutes
Travelling loaded..... 30 minutes
Returning..... 20 minutes

65 minutes at $1.00 =

$\frac{1.0833}{1.20}$ = per cubic yard..... $ .9028

Trimming dump

$\frac{.35 \text{ per hour}}{10}$ = per cubic yard..... $ .0350

Foreman, receiving 75 cents per hour straight time, will average 90 cents per hour actual time, allowing for rainy days, etc. Assuming that the entire gang is proportioned to handle the maximum amount loosened by the plow, the actual production will be

20 cubic yards per hour,
therefore, .90
20 = per cubic yard .045

The water-boy at 25 cents per hour will cost per cubic yard	.0125
	$1.3497
Contingencies, allow 5 per cent. . . . . per cubic yard	.0675
Compensation insurance:	
5 per cent on payroll	.0198
3 per cent on team-hire	0.285
	$1.4655

or $1.47 per cubic yard, exclusive of general supervision, overhead costs, and profit.

SECTION VII. BRACING

Bracing used in ordinary building excavation may consist of wood, concrete or steel sheet-piling. Concrete and steel sheet-piling may be considered as specialties usually handled by organizations specializing in that class of work.

Thickness of plank to be used for sheet-piling and the spacing of waling strips and braces will, of course, have to be determined by calculating the load which the piling must retain. This is calculated after ascertaining the weight per cubic foot of the material and its angle of repose.

However, for excavations not over 10 feet deep, 2-inch plank with 6 by 6 wales not over 5 feet apart, the wales being supported by bracing not over 7 feet apart, will usually suffice.

For excavations 10 to 15 feet deep it is best to figure upon 3-inch plank with 8 by 8 wales, not over 3 feet apart near the bottom, and for 15 to 20 feet deep 4-inch plank should be used.

Wood sheet-piling will seldom be found economical for greater depths than 20 feet.

Where union rules or other restrictions do not prevent it, the entire work of sheet-piling can be done by handy

laborers, provided they are directed by an experienced man. Where union rules require it, it will be necessary to allow for having certain parts of the work done by carpenters.

Production can be figured upon the following basis:

TABLE VIII.—SHEET PILING

Setting braces and driving piles:	
For first 10 feet of depth	10 square feet per man per hour
From 10 to 15 feet deep	9 square feet per man per hour
From 15 to 20 feet deep	7 square feet per man per hour
Pulling piles and removing braces:	
For first 10 feet of depth	40 square feet per man per hour
From 10 to 15 feet deep	35 square feet per man per hour
From 15 to 20 feet deep	20 square feet per man per hour

Of course, the men will work in a gang of two or four, but the cost is to be figured upon the basis of the production per man.

The amount of material required for sheet-piling will be determined by the number of times the piling can be used over again on the same job. On most moderate sized jobs it will be advisable to provide enough plank and bracing to enclose the entire excavation at once.

Example.—To find the cost of sheet-piling for an excavation 60 feet wide, 100 feet long and 10 feet deep. The plank will need to be at least 2 feet longer than the depth of the footing, that is, 12 feet long.

Distance around excavation 320 lineal feet

320 lineal feet by 12 feet plank by 2 inches thick ..... 7,680 FBM, plank

Wales—3 lines 6 by 6's, 320 feet..... 2,880

Braces—6 by 6's, 45 each 8 feet, 10 feet, 12 feet	4,050	
Stakes—8 by 8, 45 each 6 feet	1,485	
		8,415 FBM, bracing

The area to be piled is
320 by 10 = 3,200 square feet
3,200 ÷ 10 = 320 hours driving, etc.
3,200 ÷ 40 = 80 hours pulling
Fractional hours are here considered as full hours

7,680 FBM plank at $36. per thousand	$276.48
8,415 FBM bracing at $44. per thousand	370.26
	$646.74
Deduct 60 per cent for re-use value of lumber	387.06
	$259.68
Spikes (estimated at 20 pounds per 1,000 FBM bracing), 168 pounds at .05	$ 8.40
Labor driving, 320 hours, at .45	144.00
Labor pulling, 80 hours, at .45	36.00
Contingencies, allow 5 per cent of labor cost	9.00
Insurance, allow 5 per cent labor cost	9.00
Net cost, exclusive of supervision, overhead and profit	$466.08

Caution.—All labor rates and material prices used in this text are arbitrarily assumed. The estimator should be careful to get the actual rates and prices that will be in effect for every job for which he makes an estimate.

Whenever possible, the necessary sheet-piling and bracing should actually be designed by a competent engineer, then the amount of material to be purchased and handled can be figured more accurately.

Note also that the figures are on square edged plank, which is the most practicable. If matched plank should be specified, 15 per cent must be added to the quantity of plank, and 10 per cent must be deducted from the amount driven or pulled per hour.

Whenever an estimate is made on the cost of excavating,

a visit should be made to the place where the work is to be done, the following information obtained, and proper allowances made in the figures:

Nature of soil.
Disposal of top-soil.
Disposal of other excavated material.
Location of dump.
Necessity for spreading at dump.
Local rate for labor.
Local price for teams, etc.
Cost of any permits required.
Necessity for protecting sidewalk.
Necessity for protecting pavements.
Cost of watchman, if needed.
Cost of maintaining lights, if needed.
Cost of materials, if any are needed.

It is necessary also to include in all estimates a proper amount for general supervision, traveling expenses, home-office expense and profit. These items will be referred to again in succeeding chapters, but attention is called to them here so that they will not be lost sight of.

CHAPTER III

BRICKWORK

SECTION I. MATERIALS

While the Common Brick Manufacturers' Association has adopted a standard size, 8 inches long by $3\frac{3}{4}$ inches wide by 2 inches high, to be used for all common building bricks and for face bricks, it will probably be many years before the bricks actually used will approach uniformity in size.

Bricks sold in different parts of the country vary materially in size, and in New England alone we find them ranging in cubical contents from 60 cubic inches to 76 cubic inches, or a range of over 25 per cent.

As long as these differences in size endure, it is evident that no arbitrarily assumed figure, such as 21 bricks or $22\frac{1}{2}$ bricks to the cubic foot of wall, can be correct except by some lucky chance that the bricks delivered happen to average either 68 or 64 cubic inches in size and that they are to be laid with $\frac{1}{4}$-inch joints.

Inaccurate Methods.—Such a method, when used in estimating the cost of large quantities of brickwork, is too inaccurate for closely competitive bidding. On the other hand, when securing quotations on bricks, it is no trouble to ascertain the average cubical contents of the bricks and to adjust the estimate accordingly.

Table IX was prepared for the purpose of determining the number of bricks required and also for determining which of two or more competing makes of bricks would prove cheaper to use at the prices which might be quoted.

Tables IX and X are to be used in conjunction in order

to determine the total number of bricks and quantity of mortar needed to complete a given piece of brickwork.

TABLE IX.—NUMBER OF BRICKS REQUIRED TO LAY ONE CUBIC FOOT OF WALL

Average Volume of One Brick in Cubic Inches	¼-Inch Joint	5/16-Inch Joint	⅜-Inch Joint	½-Inch Joint
60	23.7	22.4	21.1	18.6
61	23.5	22.1	20.8	18.4
62	23.3	21.9	20.4	18.2
63	23.0	21.7	20.0	18.0
64	22.4	21.3	19.9	17.8
65	22.2	21.1	19.8	17.6
66	21.9	20.8	19.6	17.4
67	21.6	20.6	19.3	17.2
68	21.3	20.3	19.0	17.0
69	20.9	20.0	18.8	16.8
70	20.6	19.7	18.6	16.6
71	20.5	19.5	18.5	16.4
72	20.3	19.2	18.2	16.2
73	20.0	18.9	17.9	16.0
74	19.8	18.7	17.7	15.8
75	19.5	18.4	17.5	15.6
76	19.1	18.2	17.3	15.4

Valuable Catalogue Information.—Several years ago a builders' supply dealer issued a catalogue and included in it some tables of valuable information. Among them was one giving the amount of materials required to make the necessary mortar to lay 1,000 bricks.

TABLE X.—VOLUME OF MORTAR IN CUBIC YARDS, REQUIRED TO LAY 1,000 BRICKS

(12-inch Wall Basis. Full Joints on Outside. Interior Vertical Spaces Open)

Average Volume of One Brick in Cubic Inch (cubic inches)	Cubic Yards Mortar Required			
	¼-Inch Joint	5/16 Inch Joint	⅜-Inch Joint	½-Inch Joint
60	0.28	0.35	0.42	0.56
61	0.28	0.34	0.41	0.55
62	0.27	0.33	0.40	0.53
63	0.26	0.33	0.39	0.52
64	0.29	0.35	0.41	0.57
65	0.28	0.35	0.41	0.55
66	0.28	0.35	0.41	0.55
67	0.26	0.33	0.39	0.52
68	0.31	0.35	0.42	0.61
69	0.30	0.37	0.43	0.59
70	0.28	0.35	0.42	0.56
71	0.29	0.36	0.43	0.57
72	0.28	0.35	0.42	0.56
73	0.29	0.36	0.43	0.57
74	0.29	0.36	0.43	0.57
75	0.30	0.37	0.45	0.58
76	0.31	0.39	0.46	0.68

If all vertical spaces are filled solid with mortar, the above quantities must be increased 25 per cent.

For a mixture of 1 part cement, 1 part lime putty, and 3 parts sand, the catalogue gave the quantities as

0.36 barrel lime
0.75 barrel cement
0.32 yard sand,

Comparing the table with the actual results reported from jobs upon which similar mortar and width of joint had been specified, and the quantities used were found to be as follows:

	Job 1	Job 2	Job 3	Job 4
Barrel lime	0.94	0.65	0.50	0.81
Barrel cement	0.53	0.57	0.37	0.19
Yards sand	0.43	0.55	0.47	0.49

It will be noticed that none of the jobs completed furnished a very good check upon the figures given in the catalogue.

The small quantity of cement used on Job 4 is explained by the use of a local grey lime, rich in alumina, which produces a very strong mortar even when the major portion of the specified quantity of cement is replaced by lime.

Variations in Lime.—The variation in the amount of lime used on the other three jobs is probably explained by the difference in the "bulking" capacities of the different brands of lime used. For instance, three different brands show a production of putty of 2.50, 2.62, and 2.75 times the amount of dry lump lime and authorities writing on the subject give an even wider variation. From the above, it would seem that, to get the actual proportions called for in the specifications, the quantity of dry lime used should never be more than 40 per cent of the quantity of cement used.

However, the great tendency is to exceed the specified amount of lime whenever possible because it produces a smoother working mortar, which means a saving in labor cost of bricklaying even though the cost per cubic yard of mortar may be slightly increased.

Regardless of the amount of the cementing material

used, the quantity of sand used is what determines the quantity of mortar produced and the figures indicate a variation of practically 28 per cent between Job 1 and Job 2. Put in other figures, Job 1 used 400 cubic inches of sand per cubic foot of wall, while Job 2 used 510 cubic inches of sand per cubic foot of wall.

If the sand contained 33 per cent of voids, 3 cubic feet of sand and 1 cubic foot of cement should produce 3 cubic feet of mortar even if no lime were used; but, as the sand usually used will average from 40 to 50 per cent of voids, the addition of a cubic foot of lime putty cannot increase

TABLE XI.—QUANTITY OF INGREDIENTS PER CUBIC YARD OF MORTAR

(In the Proportions Column, Cement is Given First, Lime-putty Second and Sand Third)

Proportions	Barrels Cement	Barrels of Dry Lump Lime		Cubic Yards Loose Sand
		180-Pound Basis	280-Pound Basis	
1–1–3	2.28	1.21	0.82	0.94
1–1–2	3.02	1.58	1.07	0.91
1–1½–3	2.28	0.61	0.41	0.94
1–1½–2	3.02	0.80	0.54	0.91
½–1–3	1.19	3.12	2.11	1.00
½–1–2	1.76	4.61	3.11	0.99
1–3 with 10 per cent lime-putty	2.28	0.13	0.08	0.94
½ with 10 per cent lime-putty	3.02	0.17	0.12	0.91

the total volume beyond 3.70 to 3.80 cubic feet. In other words, the total volume of mortar cannot be over 1.27 times the amount of sand purchased. In actual practice, because of waste, shrinkage and other losses, the total quantity of mortar produced is very likely to be slightly less than the total amount of sand purchased.

Even when the amount of mortar per thousand bricks is determined accurately for a given size of bricks, it will be absolutely accurate only for a given thickness of wall. For instance, if a thousand bricks laid in a 12-inch wall required 0.55 cubic yards of mortar, varying the thickness of wall would affect the quantity of mortar approximately as follows:

	Per Cent	Cubic Yard
8-inch wall	94	0.51
12-inch wall	100	0.55
16-inch wall	103	0.565
20-inch wall	105	0.58
24-inch wall	107	0.59

These differences are small, it is true, and on a small building would average up so as to balance one another but, if costs were reported for a job having all 12-inch walls and those costs were used for estimating another one having all 24-inch walls, the difference might be appreciable. If a cubic yard of mortar costs $12, then the mortar for a thousand bricks in a 12-inch wall would cost $6.60 and in a 24-inch wall it would cost $7.08. On a million bricks this difference would be $480, well worth taking into consideration.

None of these tables has been carried beyond the second place of decimals. It is not believed that the accuracy attainable in scaling plans and computing quantities, or the

ccuracy attainable in measuring materials on construction ork, will warrant any greater refinement.

Some of the figures in the table of Cubic Yards of Mor-ar Required per Thousand Bricks may seem inconsistent t first sight, but, by comparing these figures with those in ne table of Bricks Required to Lay One Cubic Foot of Vall, and noting the volume of wall produced by 1,000 of given size of bricks, the apparent inconsistency will be xplained.

SECTION II. LABOR

In the previous section, dealing with the cost of the mate-ials which are used in brickwork, it was shown why it is ossible for there to be such great differences in two or ore estimates submitted for the same piece of work.

Figures were presented to show the number of bricks of arying sizes required to lay up a cubic foot of wall and ne amount of the mortar materials required for each 1,000 ricks of the size selected.

In the present section there will be presented a method figuring the cost of brickwork labor. This method is the ne that I have been using for years in my own work, and has given highly satisfactory results.

The ideal method of estimating the cost of brickwork ould be one which was worked out in as much detail as ie method evolved by Taylor and Thompson for figuring ie cost of concrete as presented in their book, "Concrete osts."

Such a method would involve the finding and tabulation the necessary unit-times for each such operation as pick-g the bricks from the pile, loading hods or wheelbarrows, elivering to scaffold, picking up, turning, placing, spread-g mortar, cutting the joint, pointing, raising the line, umbing corners and jambs, as well as a number of other erations.

Such a method would be very interesting from a theo-tical viewpoint and might reasonably be used as means

from which to develop more improved methods of handlin brickwork, with ultimate reduction in cost.

Competitive Methods.—However, present competitiv methods of doing business, as well as present labor con ditions, make it impracticable to use such detailed methods while good business demands that the method of estimatin shall be one that gives a figure which will very closel approximate the actual cost of doing the work.

If, even considering the limited time usually allowed fo the preparation of bids, the estimator could determine ex actly the conditions under which the work will be conducte and the methods that will be used, he might be justified i using minutely detailed methods of estimating.

Often the estimator will have very little to do with th actual conduct of the work after a contract is closed, so th best that he can do is to exercise his good judgment as t

TABLE XII.—COMMON BRICKWORK

(Joints Struck One Side of Wall)

	Bricks Laid per Hour	
	Using Lime Mortar	Using Cement Mortar
Wall 3 feet 0 inch thick or over...	300	250
Wall 2 feet 4 inches to 3 feet 0 inch thick.....	250	225
Wall 1 foot 8 inches to 2 feet 0 inch thick.....	225	200
Wall 1 foot 4 inches thick.....	200	175
Wall 1 foot 0 inch thick.....	175	150
Wall 0 foot 8 inches thick.....	150	125

e most desirable method of handling the work and esti-
ate accordingly.

The method which has been outlined herein is intended
be sufficiently detailed for all practical purposes and yet
t to be too theoretical. Certainly it is much better than
e ordinary method of "sizing up" a job and setting a
ice per thousand bricks on that basis.

The quantities which have been set down herein as a
rmal hourly production for different classes of work were
termined after a careful study of all the published lit-
ature, as well as by collating a great mass of personal
perience data.

While the bricklayer's wages may not always be the
rgest single item in the cost of laying bricks, the number
bricks actually laid per man per hour is usually the
termining factor in fixing the cost of the work.

Table XII gives the average production that may be
pected from competent bricklayers working under aver-
e conditions:

If there be more than the usual number of openings in
e wall, or if there be many pilasters which require plumb-
g, an allowance of 5 minutes of bricklayer's time for each
ear foot of plumbing should be made.

If joints on both sides of the wall must be struck, the
oduction will be about 10 per cent less than the figures
ven above.

Just at present the actual production in the New Eng-
nd States will only run about 85 per cent of the tabular
gures, but the proper kind of management should succeed
getting 100 per cent of those figures.

Other special and fancy bonds will decrease the produc-
n, as also will the introduction of many pilasters, open-
gs, paneling, etc.

Laborers' Work.—The number of laborers, or tenders,
quired is, of course, determined by the number of bricks
ing laid, the distance the bricks must be moved, neces-
y of culling bricks and other factors. The ratio may be

TABLE XIII.—FACE BRICKWORK

	Bricks Laid per Hour	
	Lime Mortar	Cement Mortar
Running bond plain cut joints	90	80
Running bond V-joints	70	60
Running bond raked-out joints	70	60
Running bond raked-out and struck smooth	65	55
Flemish bond plain cut joints	65	55
Flemish bond V-joints	60	50
Flemish bond raked-out and struck smooth	50	45
Flemish bond rodded joints	45	40

anywhere from four laborers to each five bricklayers up three laborers to one bricklayer.

The following information will be helpful in determini the number of laborers necessary:

One mortar mixer, working 9 hours, can produce abo 4 cubic yards of sand-cement or sand-lime-cement morta

The cost of handling and storing cement for mortar discussed in Chapter VI.

One laborer can load and wheel about 1,120 bricks distance of 40 feet per hour, using barrows, and dump the on the scaffold.

Using a hod, he can make more trips but will probab only transport about one-half as many bricks per hour he will with barrows.

One laborer can handle about 500 brick per hour fr car to wagon or from wagon to pile.

One laborer can cull from 200 to 300 bricks per hour, epending upon the quality of the bricks delivered and the ringency of the inspection.

One laborer, using a barrow, can deliver about 33 cubic eet of mortar a distance of 40 feet in one hour.

Two good laborers working together can handle about 6 linear feet of pole-staging per hour.

On thick walls one laborer can build, take down and ove horse-scaffolding for twelve bricklayers. On thinner alls the work goes up more quickly so that more men are eeded to build scaffolds. A fair ratio would be to de- rease the number of bricklayers to each scaffoldman by wo bricklayers for each decrease of 8 inches in thickness f wall below 3 feet. It is, of course, assumed that horse- caffolding will not be used for any walls above normal tory height.

It has not been attempted to include figures here for the reat variety of patented scaffolds. The estimator who has ccasion to figure on their use usually can get the necessary nformation from the manufacturers or from persons who ave used them.

Elevating.—Two laborers, with a chain hod-elevator, can levate 2,500 bricks a distance of 30 feet in 1 hour.

A two-barrow elevator, operated by a motor or steam ngine, can elevate 10,000 bricks a distance of 30 feet per our.

Hauling.—A two-horse team will travel with the empty agon at about 3 miles per hour or at about 2 miles per our with the following loads:

TABLE XIV.—HAULING BRICKS

n poor earth roads...	2,000 lbs. equal to	370 aver. bricks
n fair earth roads...	2,500 lbs. equal to	465 aver. bricks
n good earth roads..	4,000 lbs. equal to	750 aver. bricks
n hard surfaced roads	6,000 lbs. equal to	1,110 aver. bricks

Of course, steep grades will reduce both the load and th speed of travel.

Motor trucks can be figured to carry their rated loading at an average safe speed of 8 to 12 miles per hour, and, c course, the same proportionate time must be allowed fo loading and unloading as for wagons drawn by horses.

SECTION III. EXAMPLES

Example 1.—As previously stated, the quantities give herein are the average of a great number of published dat and considerable personal experience. Actual productio will vary very widely in different parts of the country an at different times.

Every estimator in active practice should have his ow data book, covering the experience of his own organizatio and those data will reflect the skill of the workmen em ployed as well as the organizing and executive ability of th foremen, superintendent, and higher officials.

However, by substituting the proper quantities and tak ing due account of all local conditions, this method of est mating may be used for practically every job.

As a typical example, we may take the case of an ord nary brick mill building, four stories high, with interi brick walls, enclosing the stairways. We will assume th the dimensions are 80 feet by 200 feet and the thickness the walls as follows:

	Exterior (inches)	Interior (inches)
First story	20	16
Second story	16	12
Third story	16	12
Fourth story	12	12

Figuring the quantity of bricks by the usual method, and educting all openings, we find that the job will require bout 641,000 bricks, distributed as follows:

164,000 in 20-inch walls on first story
29,000 in 16-inch walls on first story
139,000 in 16-inch walls on second story
139,000 in 16-inch walls on third story
22,000 in 12-inch walls on second story
22,000 in 12-inch walls on third story
126,000 in 12-inch walls on fourth story

The method of computing the amount of mortar mate-ials required was explained in the previous chapter and ill not be repeated here. This is to be an estimate of the bor cost only, and it will be assumed that the sand, cement nd lime have been purchased for delivery at the site and iat the bricks must be hauled from the siding 2 miles away ver good earth roads and that teams are more readily vailable than motor trucks.

It will also be assumed that the stocks of lime, cement, nd and bricks will be disposed about 25 feet away from ie building and that a steam elevator will be used:

Rates of pay are assumed as follows:

ricklayers..... 90 cents per hour
aborers..... 50 cents per hour
eams..... 100 cents per hour
levator—Flat-rate of $20 per day, including engineman, fuel, raising for additional stories, etc.

Horse-scaffolding will be used throughout, working from ie floor construction and the outside bricks will be laid overhand."

Evidently the first thing to do is to get the bricks from ie siding to the site, so we will figure that cost first.

Since the team can haul 750 bricks to a load, and since laborer can handle 500 bricks per hour from car to wagon, will take two men about 45 minutes to load a wagon, or

where the driver helps to load, it will require only 30 minutes.

The cost per trip is, therefore, as follows:

Team:		
Loading time	30 minutes	
Traveling loaded at 2 m.p.h	60 minutes	
Dumping	5 minutes	
Returning at 3 m.p.h	40 minutes	
	135 minutes	
135 minutes at $1 per hour		$2.25
Men:		
2 men, each 30 minutes, 60 minutes		.50
Cost for 750 bricks		$2.75

This equals $3.67 per thousand net, so we will use a figure of $3.70 to allow for a few minor contingencies.

It has been assumed here that a sufficient number of teams will be employed to keep the men at the car busy; otherwise their waiting time must be figured into the cost of the work.

In most places it will be found practicable to employ lower priced men for unloading cars, and the figure above may be varied accordingly.

From the method given in the previous chapter, we find that about 266 cubic yards of mortar will be required, to be used as follows:

86 cubic yards on the first story
65 cubic yards on the second story
65 cubic yards on the third story
50 cubic yards on the fourth story

Because a job of this size will hardly tax the full capacity of the elevator, the cost of hoisting need not be figured separately for each floor but can be covered by a single item, as will be shown later. Where a building is very high or the number of bricklayers great enough to use the full capacity of the elevator, it is well to estimate the amount

of materials to be hoisted to the various heights and to figure accordingly.

From the dimensions of the building and the locations of the piles, it will be seen that the greatest horizontal distance that materials will be transported is about 305 feet, and the average about 165 feet.

Total Mortar Cost.—Therefore, the total cost of making and delivering the mortar will be as follows:

Making 266 cubic yards at 4 cubic yards per 9 hours 598.5 hours at 50 cents	$229.25
Transporting 266 cubic yards (using barrows), average distance 165 feet at 33 cubic feet per hour for 40 feet 896.3 hours at 50 cents	448.85
Labor cost of mortar	$748.10

The next item is the cost of building the scaffolding. Figuring three scaffolds per floor (if we can work from the floor plank, we shall only need two scaffolds per floor) above the first and two on the first floor, we find that we need 6,160 feet of scaffolding which must be built, taken down and rebuilt rapidly enough to provide for the number of bricklayers employed.

This job appears to require about 512 hours of scaffold builders' time which at 50 cents per hour equals $256.

The cost of taking the bricks from the pile and transporting them, by barrows, to the scaffold, an average horizontal distance of 165 feet at the rate of 1,120 bricks 40 feet per hour, will be 2,361 hours at 50 cents equals $1,180.50.

Actual laying of the bricks will figure out as follows:

20-inch walls $\frac{164,000}{200} = 820$ hours

16-inch walls $\frac{307,000}{175} = 1,754$ hours

12-inch walls $\frac{170,000}{150} = 1,133$

3,707 hours @ 90 cents $3,336.30

Since the walls on this kind of a job must be pointed on both sides, the production will be decreased 10 per cent which means that the number of hours must be increased by one-ninth, thus:

Pointing, 412 hours at 90 cents 370.80

If the average force is to be fifteen bricklayers, the job will run for at least 35 working days but, since allowance must be made for rainy days and other delays, we shall probably have to have a mason foreman on the job for at least 40 days, and his rate will be about $48 for a 5½-day week or 7.3 weeks, which equals 350.40

Since all of the bricks above the first floor must be elevated, we shall require the elevator for 22 of the 31 working days, and this will cost, at $20 per day 440.00

We now have a total of $6,682.10

for the labor cost on the job (which is an average cost of $10.42 per thousand) and to this must be added the cost of unloading and carting which, at $3.70 per thousand equals 2,371.70

(Of this amount approximately $448.70 is payroll and $1,923 is team hire.)

To wash down the building, we shall require two bricklayers and two laborers, each working 7 days of 8 hours each, or a cost of 156.80

Labor Total $9,210.60

Compensation insurance, figured as 5 per cent on payroll and 3 per cent on team hire will be ... 422.07

$9,632.67

Extra Costs.—To this figure must be added the cost of supervision, building shanties, any contingent items

which local or seasonal conditions make necessary, office expense and profit.

No attempt has been made to discuss such items as cutting and grinding brick for arches, building quoins or ornamental cornices, though proper allowance must be made for each such item. However, it is almost impossible to set down figures that will be of any value without examining the design in each case. The usual allowance is 10 minutes of bricklayers' time for each brick that must be cut and ground and 10 minutes per running foot of each projecting course. These amounts are added to the total cost of doing the work.

Short Method.—A much shorter method of estimating and one which, while it is neither so accurate or so detailed as the one described above, may be used where the estimating time is limited, is outlined in the succeeding paragraphs.

The job which we have just been considering is a "fair average" of what comes to the contractor who specializes in industrial buildings, and it brings out the following facts:

The total number of hours of bricklayers' time, exclusive of foreman or of cleaning down but including the extra pointing, is 4,119, and the average number of brick to be laid per hour is 173, or 1,384 per 8-hour day.

The total number of hours of laborers' time, exclusive of unloading and carting or cleaning down, is 4,367.8, or, in other words, for each 8 hours of bricklayers' time we shall require almost 8½ hours of laborers' time, including the scaffold builder.

We need also 0.09 day of the foreman's time and 0.05 day of the time of the elevator.

Using these figures:

8 hours bricklayer at 90 cents	$7.20
8½ hours laborer at 50 cents	4.25
.09 day foreman at $8.75	.79
.05 day elevator at $20.00	1.00
	$13.24

Taking the day's production as 1,384 bricks laid, less 10 per cent for extra pointing, we get 1,246 bricks laid.

$$\frac{\$13.24}{1246} = \$10.60$$

per thousand, to which must be added the insurance, cost of unloading, hauling, etc., as though we were using the more detailed method.

It will be noticed that the result obtained, $10.60 per thousand, corresponds fairly closely with the figure of $10.42 obtained by the detailed method. It must be remembered, however, that if we were using this latter method in actual practice we should probably use some arbitrary figure, such as 1,250, 1,300, 1,350, or 1,400 bricks laid for a day's work, and should then get the following costs, respectively, $10.59, $10.19, $9.81, or $9.46 per thousand.

While the relative number of hours for the two classes of men will change but little over a wide range of sizes of mill-type buildings, the daily production will vary widely and should always be calculated as closely as circumstances will permit.

The amount of foreman's time and elevator time will be governed largely by the number of men that can be employed and that number in turn, by the size of the building and other conditions, and these two items may vary as much as 50 cents to $1 per thousand in the cost of the work.

Whichever method of figuring is used, the cost of culling the bricks for facing, where such is necessary, must be added.

Example 2.—Where pressed or face bricks are used, it will usually be necessary to figure on two scaffolds, an inside scaffold for the backing and an outside scaffold for the facing.

It should also be remembered that, because of the added unit weight of pressed bricks and the greater care required in handling any kind of face bricks, the number handled by

the laborers in a given time will be only from two-thirds to three-fourths as many as the number of common bricks handled in the same length of time. The best method is to make a separate item in the estimate for common brickwork and one for face brickwork.

For instance, if the building under consideration had been faced on one side and one end with pressed bricks, our quantities would have been as follows:

69,000 pressed bricks
82,000 common bricks in 20-inch walls
234,000 common bricks in 16-inch walls
211,000 common bricks in 12-inch walls
45,000 common bricks in 8-inch walls

This will change our estimate on the bricklayers' time as follows:

$$\text{20-inch walls } \frac{82{,}000}{200} = 410 \text{ hours}$$

$$\text{16-inch walls } \frac{234{,}000}{175} = 1{,}338 \text{ hours}$$

$$\text{12-inch walls } \frac{211{,}000}{150} = 1{,}405 \text{ hours}$$

$$\text{8-inch walls } \frac{45{,}000}{125} = 360 \text{ hours}$$

$$3{,}513 \text{ hours}$$

The cost of the making the mortar will be practically the same as before, as will also the cost of the hoisting, so we shall simply pro-rate those two items to the different classes of brickwork as follows:

	Face Brick (69 thousand)	Common Brick (572 thousand)
Mortar Cost	$80.53	$667.57
Hoisting Cost	47.25	392.75

The cost per thousand of hauling the common bricks will be the same as before but the pressed bricks will weigh more and must be handled more carefully, the load being only

625 bricks. The loading time is the same as before but the bricks must be unloaded and piled instead of being dumped.

The hauling cost will, therefore, be as follows:	
Team, moving 100 minutes, loading 30 minutes, unloading 30 minutes; total 160 minutes at $1. per hour	$2.67
Men, two, each 30 minutes loading and 30 minutes unloading	1.00
Cost for 625 bricks	$3.67
which equals $5.87 per thousand, or, say, $5.90.	
The cost of placing the common bricks upon the scaffold will be proportionally as before, 2,177 hours at 50 cents, which equals	$1,088.50
The cost of placing the face bricks upon the scaffold (figuring 840 per hour instead of 1,120 per hour) will be 83 hours at 50 cents, which equals	41.50

Note.—The location of the hoist and stock piles, with respect to the sides requiring pressed bricks, will influence the cost of this item. For convenience the same distance as before has been assumed.

The cost of laying the face bricks will be $\frac{69,000}{90}$ at 90 cents per hour	$690.00

A pole-scaffold will be required for the face bricks and there will be 11 lines of scaffold, 280 feet long or 3,080 linear feet. This will require 385 hours laborers' time, which at 50 cents per hour equals $192.50.

A summary of the face-brick estimate will, therefore, be as follows:

Carting 69,000 bricks at $5.90 per 1,000	$ 407.10
Mortar	80.50
Hoisting	47.25
Handling	41.50
Laying	690.00

Scaffold	192.50
Cleaning down (one-half of building faced)	78.40
Total	$1,537.25

(equals $24.14 per 1,000 or $18.24 per 1,000, exclusive of carting).

The summary of the cost of laying the common bricks will be as follows:

Carting 572 thousand at $3.70	$2,116.40
Cost of making mortar	667.57
Cost of hoisting	392.75
Scaffold (as before)	256.00
Handling	1,088.50
Laying—3,513 hours at 90 cents	3,161.70
Extra pointing time (since only 399 thousand of the common brick will be in walls requiring pointing on 2 sides, this figure will be: $\frac{1}{9}$ by $\frac{399}{572}$ by 3,513 = 272 hours at 90 cents	244.80
Cleaning down (one-half of building)	78.40
	$8,006.12

Which equals $13.98 per thousand, of $10.28 per thousand, exclusive of the cost of carting

Now, our combined brickwork figure will be made up as follows:

Total cost of face brickwork	$1,537.25
Total cost of common brick work	8,006.12
Foreman—figured on the same basis as before, but for 44 days instead of 40	384.00
Total labor cost	$9,927.37

To this must be added the cost of compensation insurance and all the other items of overhead expense, as previously explained.

CHAPTER IV

STONE WORK, CEMENT BLOCK WORK, ARCHITECTURAL TERRA-COTTA

SECTION I. STONE FOUNDATIONS. RUBBLE STONE

While it is true that stone foundation work has been almost entirely superseded by concrete in many parts of the country, it is essential that the well-informed estimator be familiar with the methods of figuring its cost.

It is also improbable that the time will ever come when there will not be some call for high-grade jobs of rubble stone work, because no other form of construction can produce the same variety of artistic effects.

Since the range of sizes and shapes of stones available for rubble stone work will vary widely, hardly any two lots of stone will work out alike, it is not practicable to develop as detailed, or as accurate, a method of estimating rubble stone work as is practicable for cut stone work, brickwork, or for concrete work.

This makes it necessary to resort more to the method of assumptions than when estimating brickwork or concrete, but nevertheless the estimator should strive to accumulate all the experience data that he can, taking care to record his data so that they can readily be used for the purpose of estimating those features of any new work that are comparable with similar features of previous work.

Every estimator will do well to record the cost, in man-hours, of the various operations on any rubble stone job coming under his observation and to compare it with the information contained in this section.

In this portion of New England, it is quite usual to build

tone foundations from old stone fence-walls and, when this s done, the question of estimating the cost of obtaining the tones is very simple.

In other cases, when it is necessary to obtain the stones rom the field, the cost can only be obtained by deter- nining, as nearly as possible, the necessary time required o assemble them into piles and load them into the carts r wagons, and this time will be determined by the fre- quency or scarcity of stones in the field that are suitable or use in the work.

Where the stones can be taken from a gravel-pit or from fence-wall and the sizes are such that they can be loaded y hand, the following figures may be used:

TABLE XV—GETTING OUT THE STONE

(Time in Labor Hours per Cubic Yard)

	From Pit to Wagon	From Wall to Wagon
mall round cobbles or boulders	0.72	0.66
arge round cobbles or boulders	0.78	0.70
mall split stones	0.67	0.60
arge split stones	0.73	0.65

Waiting time of wagon, waste time between wagons and imilar costs must be figured as explained in Chapter V in onnection with Concrete Construction.

When it is necessary to wheel the stone from the pit or all to the wagon, the cost must be figured as an extra to ne above and one man can load and move one cubic yard f stone an average of 100 feet per hour.

Allowance for Openings.—When figuring the quantity f stone and mortar required, allowance may be made for ne various openings in the wall and the actual cubical ontents taken but, when figuring the cost of the labor, it

is well to remember that stonemasons who take rubble-stone work by sub-contract usually insist upon measuring entirely around the outside of the foundation and not allowing for any ordinary openings.

They usually also insist upon figuring upon a minimum thickness of 18 inches, no matter what the actual thickness of the wall may be.

This is done because there is practically no available data as to the cost of building jambs and corners, so the assumption is made that the saving by reason of the openings will balance the added cost of the jambs and corners. It is also assumed by the masons that it takes just as long to build a wall 12 inches thick as it does to build a wall 18 inches thick, because of the greater care required in selecting stones and plumbing the wall.

The discussion of the cost of producing mortar for brickwork, given in Chapter III, applies equally to the cost of

TABLE XVI—BUILDING THE WALL

(One and Two-man Stone)

	Hours Required per Cubic Yard			
	18 inches to 30 inches thick		30 inches to 48 inches thick	
	Flat Split Stone	Cobbles	Flat Split Stone	Cobbles
Masons	2.5	6.25	1.75	5.25
Laborers	2.5	5.25	2.5	5.25
Cubic feet mortar per cubic yard	7	7	8	8

producing mortar for stonework whether it be rubble-stone or cut stone.

Scaffolding for all walls over 4 feet in height must be figured as explained in Chapter III and added to the costs obtained from these figures.

It was formerly the custom to pay for stonework by the perch, and that unit is still in vogue in many parts of the country, but just what constitutes a perch seems to be subject to some disagreement. The most commonly accepted definition is 16.5 square feet of 18-inch wall, or 24.75 cubic feet.

For this reason the cubic yard is recommended as the most satisfactory unit for use in figuring rubblestone work.

In the section on stone setting we go into a great deal of detail as to the methods to be employed in estimating the cost of setting cut stone, ashlar facings, and other ornamental work, as well as the use of hand and power derricks in stonesetting.

However, estimators are called upon to figure stone foundations in which it is necessary to split the stones and roughly square them for laying, either in coursed or random ashlar or in cobweb rubble.

Of course, the more nearly rectangular in shape the stones are, the less mortar will be required for laying with a given thickness of joint and the amount required will also be less as the size of the individual stones increases.

The following tables will give the time necessary to prepare the stones and lay them:

When the individual stones run much over one-half cubic foot each, it will be necessary to set them with a derrick. For most ordinary work a hand derrick will give very efficient service, but on large operations a power derrick can be employed.

In another chapter the methods used in figuring the charge for power equipment are discussed, so it is only necessary for the present to consider the cost of the direct labor, foreman, water-boy, etc.

In addition to the actual cost of laying the stones in the

TABLE XVII—PREPARING STONE

(Production in Square Feet per Hour, Cutter's Time)

	Freestone	Granite
Hammered faces	1.25	1.00
Beds and Builds	2.50	2.00
Fine hammering	0.50	0.40

TABLE XVIII—LAYING STONE

(Labor Hours per Cubic Yard)

	Cobweb Rubble	Random Ashlar	Coursed Ashlar (Courses up to 18 inches high)	Coursed Ashlar (Courses 18 to 32 inches high)
Mason	6.25	7	6	5.25
Laborer	4.75	5	6	5.25
Cubic feet of mortar per cubic yard	4	4	4	3

wall, a very important item in the cost of stone-work is that of pointing the exposed areas and, since the kind and quality of work demanded varies greatly, the cost varies accordingly. Table XIX gives the data necessary for computing the cost of the labor.

Note.—This table is based upon having one laborer tend three masons; if that ratio cannot be maintained proportionate allowance must be made in the estimate.

Example.—Assume that the foundation for a church

TABLE XIX—POINTING

(Square Feet of Surface per Hour)

	Mason	Laborer
Flat stone work, joints raked out	20	60
Small cobble work, joints raked out	20	60
Large cobble work, joints raked out	30	90
Cobweb rubble, joints raked out	30	90
Random ashlar	30	90
Coursed ashlar	30	90
Cobweb rubble, smoothed joints	20	60
Random ashlar, smoothed joints	20	60
Coursed ashlar	20	60
Cobweb rubble, ribbon joints	10	30
Random ashlar, ribbon joints	10	30
Coursed ashlar, ribbon joints	10	30

building is to be 80 feet long, 40 feet wide, and 10 feet high. The 6 feet from bottom of the wall to grade are to be ordinary flat stone work, but from grade to top is to be coursed granite ashlar. The outside walls above grade are to be pointed smooth, and the inside face from bottom to top is also to be pointed smooth. The wall is to be two feet thick.

The flat stones are available on the lot but the granite is delivered to a railroad station a mile away. The mortar materials are furnished at the job, which is quite a usual practice in some sections of the country where stonework is sublet by general contractors to men who specialize in stone-setting.

Masons' wages are $1. per hour
Laborers' wages are $.50 per hour
Team hire is $1.25 per hour

The quantities involved are evidently as follows: Perimeter of wall equals 240 linear feet,

therefore,

the flat stone work is 240 feet by 2 feet by 6 feet. = 106.7 cubic yards

and the ashlar is 240 feet by 2 feet by 4 feet = 71.2 cubic yards

The area of ashlar to be pointed is

Inside 224 feet by 4 feet = 896 square feet
Outside 240 feet by 4 feet = 960 square feet

1,856

The area of rubble to be pointed is

224 feet by 6 feet = 1,344 square feet

Masons' time

Laying flat stone, say 107 yards @ 2.5 = 267.5 hours
Laying ashlar, say 72 yards @ 6 = 432 hours

Pointing flat stone $\frac{1,344}{20}$ = 67.2 hours

Pointing ashlar $\frac{1,856}{20}$ = 92.8 hours

Total mason time 859.5 hours @ $1 ..... $859.50

Laborers' time:

On laying flat stone 107 yards @ 2.5 = 267.5
On laying ashlar stone 72 yards @ 6 = 432

On pointing flat stone $\frac{1,344}{60}$ = 22.4

On pointing ashlar $\frac{1,856}{60}$ = 31

Scaffolding:

Quantity of wall above 4 feet from cellar bottom is 107 cubic yards as follows:

72 yards ashlar @ 6 = 432
35 yards ashlar @ 2.5 = 87.5

517.5 hours

mason time, and since 1 man can build scaffold for 12 masons, the time required will be 43.1

796

hours @ .50 398.00

Total cost of labor at job..... $1,257.50

To this cost must be added the premium which will be paid to one of the masons for acting as foreman, the cost of liability and compensation insurance, overhead expenses, and profit.

The cost of hauling the granite must also be added, and this is to be figured as indicated in Section V.

From the tables it is evident that 38.4 cubic yards of mortar will be required, and a complete estimate of the cost of the wall would include the hauling mentioned, the mortar and the price of the granite at the depot, as well as all of the items shown above.

SECTION II. CEMENT BLOCK WORK

The most common size of block used is 8 inches thick, 16 inches long, and 8 inches high, and it weighs from 50 to 60 pounds, depending upon the percentage of core-voids and the density of the concrete used. Blocks 12 inches long and 8 inches high, as well as other shapes, are also used but not so extensively as the 16 inch by 8 inch size.

In addition to the "stretcher" blocks, it is necessary to have corner and jamb blocks, as well as lintels. On the better jobs, short stretchers will be provided to make closures.

Various methods of organizing are used for cement block work, but the most satisfactory method seems to be to have a helper for each mason, to assist in lifting the blocks onto the wall, and one man to mix mortar and serve it to each two masons.

Additional men will be required to bring the blocks from the piles and distribute them along the wall, since the

helper cannot be expected to handle them for a greater distance than 10 feet without delaying the mason.

Makers of cement-block machinery and dealers in the blocks consider about 260 blocks, including jambs and corners, to be a fair amount to lay in an 8-hour day. The figures in our table are more conservative.

TABLE XX.—LAYING CEMENT BLOCKS

(Time in Hours per 100 Blocks)

Mason	3.8
Helper	3.8
Mortar-man	1.9
Wheelers (per each 100 feet distance to pile)	0.8
Loading or unloading trucks, laborers' hours	0.5
Add for each linear feet of corner or jamb to plumb masons' hours	0.06
Add for each linear foot of ornamental projecting corners, masons' hours	0.05
Mortar, cubic yards	0.2

This table will hold good for walls up to 12 feet in height but, since cement-block walls are seldom used for buildings having a greater story height, it is not necessary to compile a table for greater heights. When the building is more than one story high, allowance must be made for elevating as explained in brickwork.

The time for loading onto or unloading from wagons or trucks is given in the table, and knowing the weight of the blocks, you can compute the cost from the knowledge you have gained in studying the previous chapters.

Example.—Assume that we have a building 200 feet long, 70 feet wide, and 12 feet high, with 48 steel-sash each 6-0 by 8-6, 2 doors 10-0 by 10-0, and 3 doors 3-0 by 7-0 and we wish to compute the labor cost of laying the blocks

The wall area is evidently:

(2) by 200 = 400
(2) by 70 = 140

540 linear feet by 12 feet high..... 6,480

less

(48) by 6–0 by 8–6.....2,448
(2) by 10–0 by 10–0..... 200
(3) by 3–0 by 7–0..... 63 2,711

square feet 3,769

Disregarding the thickness of the joints $3,769 \times 144 \div 128 =$ 4,240 blocks required

Assume laborers' rate..... $0.45 per hour
Assume masons' rate..... 0.90 per hour

Blocks delivered by trucks to site and unloaded 100 feet from working point.

For each 100 blocks the time to be consumed at the job is, therefore, as follows:

Laborers:

	hours	
Unloading	0.5	
Wheeling	0.8	
Mortar-man	1.9	
Helper	3.8	
	7.0 @ .45	$3.15
Mason:	3.8 @ .90	3.42
Cost to lay 100 blocks		$6.57

But we must add the cost of plumbing the corners and jambs, which is,

	linear feet
4 corners @ 12 feet	48
96 window jambs @ 8½ feet	816
4 door jambs @ 10 feet	40
6 door jambs @ 7 feet	42
	946 @ 0.06 = $56.76

hours

4,240 blocks laid @ $6.57 per hundred	$278.57
57 hours time plumbing corners, etc. @ .90	51.30
Total labor cost	$329.87

If we use a mortar made of 1 part cement, 3 parts sand and 10 per cent lime putty, the cost of the mortar materials would be figured as follows:

2.28 barrels cement @ $2.80	$6.38
0.08 barrels lime @ $4	.32
0.94 cubic yards sand @ $1 25	1.18
Per cubic yard	$7.88

4,240 blocks @ 0.2 cubic yard per 100 = 8.48 cubic yards
8.48 cubic yards @ $7.88 ..... $66.82

The cost of scaffolding is figured as indicated in Chapter III.

SECTION III. MAKING CEMENT BLOCKS

No attempt is made here to cover completely the method of estimating the cost of producing the blocks, since they are usually made in factories and delivered to the job at a fixed price per block. However, a few words on the subject will not be inappropriate.

The cost of making the blocks varies widely with the equipment used; thus of two apparently prosperous plants I recently visited, one, using mechanical tampers, mechanical conveyors, industrial cars, etc., with a gang of eight men, working 9 hours per day, turns out an average of 3,300 dry-tamped blocks per day. The other plant, with all hand operations and a gang of three men at work, turns out 700 similar blocks per week.

Assuming a labor rate of 45 cents per hour, which is probably higher than actually paid, their costs would be as follows:

Mechanical plant, 8 by 0.45 by 9 ÷ 3,300 = 1 cent per block
Hand plant, 3 by 0.45 by 9 by 6 days ÷ 700 = 10.41 cents per block

The cost of the materials used depends entirely upon the mix used, and most block-makers are not very definite in stating what mix they use. However, this may be roughly estimated by assuming that the usual mix is not much higher than 1 to 5, which requires 1.20 barrels of cement and 1 yard of sand per cubic yard.

Thus:	1.20 barrels cement @ $2.80	$3.36
	1 cubic yards and @ $1.25	1.25
	1 cubic yard mortar will cost	$4.61

Since each block of the size under consideration contains 704 cubic inches of motar, a yard will make 27 times 1,728÷704=66.2 blocks, which would mean that the material cost of each block would be approximately 7 cents.

Assuming usual overhead costs, the comparison of the two plants will be as follows:

	Mechanical Plant	Hand Plant
Materials	.07	.07
Direct Labor	.01	.104
Overhead (50 per cent of labor)	.005	.05
Total	.085	.224

Whenever occasion requires the making of an estimate of the cost of producing cement blocks, it is essential to get complete data as the equipment available, mixture to be used, size and cross-section of blocks, and all other factors which affect the cost.

Care should also be taken to differentiate between dry-tamped blocks and wet-poured blocks.

SECTION IV. ARCHITECTURAL TERRA-COTTA

In estimating the cost of setting all sorts of ornamental work, as well as natural stone ashlar, the cubic foot seems to be the most satisfactory unit of calculation and as a

basis in figuring architectural terra-cotta, though others figure it by the square foot of surface area and some by the ton. The individual block seems to be the most satisfactory unit for figuring cement block work.

One "Estimators' Hand-book" says that "architectural terra-cotta is of special design and has to be figured accordingly." That is very enlightening, except that the book does not tell how to figure it accordingly.

Architectural terra-cotta is essentially a manufactured product and the matter of estimating the cost of production is no more within the province of the construction manager than is estimating the cost of producing any other manufactured article.

It is true that the man who has carefully kept the data as to the cost of terra-cotta on previous jobs is in a position to approximate the cost of similar jobs in the future. However, the price of terra-cotta is varied by so many factors, such as finish, amount of ornament, number of times any piece is duplicated, color, etc., etc., as well as manufacturing conditions and transportation costs, that it is always wise to get a definite quotation based upon the plans and specifications in every case.

Such a quotation may or may not include all necessary anchors. If it does not, then it is necessary to secure a list of those anchors from the manufacturers, or from the architect or the plans, and secure a price for them. When a lump-price for the anchors is not obtainable, their weight can readily be calculated by the tables in structural steel hand-books and their cost estimated at the current price for builders' wrought iron work.

Terra-Cotta Like Cut Stone.—Setting architectural terra-cotta is an operation very similar to setting cut-stone work, except that its lighter weight usually obviates the necessity for using derricks with terra-cotta and, in those sections where the trades are separated, terra-cotta is more usually set by bricklayers than by stone-setters. When any fitting is necessary at the job that also is done by brick-

layers, generally by those who are particularly expert in the work, rather than by stone-cutters.

On work involving any large amount of terra-cotta, it is well to make sure that the price made by the manufacturer includes the cost of necessary fitting to take care of any inaccuracies in the dimensions of the several pieces. It is hardly practicable for the builder to estimate the cost of fitting, since it may be absolutely nothing on one job and run to several hundred dollars on another and similar job.

When scaling quantities of terra-cotta from plans, it is necessary to take the full "squared" size of all mouldings, projections, capitals, columns, and similar members and multiply the dimensions into cubic feet. On that basis, the average weight will be between 70 and 75 pounds per cubic foot and the cost of hauling may be figured accordingly.

The cost of the scaffold, when figured separately, may be computed according to the data given in the discussion of brickwork. There will be many times when the terra-cotta will be laid from the same scaffold as that used for the bricklaying, so no separate item need be made.

The cost of handling the terra-cotta from car to truck, truck to wheelbarrows, to the building, sorting and distributing it, as well as setting and cleaning down, may be computed from the following tables:

TABLE XXI.—UNLOADING TERRA-COTTA

(Labor Hours per 100 Cubic Feet)

From car to truck	3
From truck to barrow	3
Wheeling 100 feet	3
Sorting and distributing	8

(Estimate cost of elevator as explained in brickwork.)

TABLE XXII.—SETTING AND BACKING (PER 100 CUBIC FEET)

	Setting T. C.	Backing
Bricklayer	8 hours	4 hours
Laborer	16 hours	4 hours
Mortar	0.16 cubic yard	.....
Brick for backing	.....	8

TABLE XXIII.—CLEANING AND POINTING

(Hours per 100 Square Feet)

	Washing Down New Work	Pointing New Work	Cleaning Old Work	Pointing Old Work
Mason	1.5	1.5	2	2
Laborer	0.75	0.75	1	1

SECTION V. Cut Stone Work

As with architectural terra-cotta, the production of cut-stone has become a manufacturing proposition and is seldom undertaken by a general contractor.

We shall therefore limit ourselves to discussing how to estimate the cost of installing the stone in the building, as that is all that the building-estimator generally finds it necessary to estimate himself.

Usually, when there is any appreciable amount of stone to be used in a building, the companies bidding on it will name a lump-sum figure for all of the stone required. They will also give their estimate of the number of cubic feet to be set, thus relieving the general contractor of the necessity of scaling the quantities again, unless he desires to check the figures.

There are many items of stone-work, such as sills, lintels, pier-caps, chimney-caps, steps, bond-stones, etc., upon which it is possible to secure unit price lists in many localities, and when this is possible, it is well to be equipped with such lists and use them in estimating, even though the figures may be checked by sub-bids.

When using such lists, it is well to be very careful to make sure that the list covers exactly the same sizes, kinds of finish, etc., that are called for by the plans and specifications, as it is possible that there may be a very appreciable variation otherwise.

When any special work or ornamentation at all is required, it is very necessary to get special prices.

The cubic foot, as previously stated, is the most convenient unit for use in figuring stone-work but, of course, the number of cubic feet that can be handled in a unit period of time will be determined by the size and weight of the individual pieces, their shape, and their position in the work.

Such items as sills, lintels, steps, pier-caps, etc., are usually set by hand, one or more laborers assisting the mason as may be required, but when ashlar facing is used, or when very much ornamental work, such as columns, cornices, etc., is included, it is customary to use a small hand-derrick or a breast-derrick.

Profitable Use of Derrick.—Where the individual pieces are heavy, or where the total quantity to be handled runs into several thousand feet, it may be profitable to use a power derrick. However, this should be studied carefully, because it often develops that the mason will not handle the stone rapidly enough to pay the added cost of the power equipment and the men to run it, to say nothing of the cost of installation, fuel and removal.

The information given in Chapters III and VI will enable the estimator to figure the cost of hauling, scaffolding, elevating, etc. The cost of loading and unloading will be determined by the facilities available. (See Table XXIV.)

If the stones are large, and no derrick is available for moving them from the car to truck and truck to building, the cost will naturally be higher than where the unloading facilities are good or the stones small.

The following tables contain the information necesary for the preparation of an estimate on any ordinary work.

Most architectural stone-work must be laid in non-

TABLE XXIV.—UNLOADING CUT STONE

(Labor Hours per 100 cubic feet)

	Hand Work	Hand Derrick	Power Derrick or Crane
From car to truck	4	3	2½
From truck to barrow or storage	4	3	2½
Wheeling in barrows per 100 feet	3	.....	.....

TABLE XXV.—SETTING CUT STONE

(Hours per 100 cubic feet)

	Hand Work		
	Sills, Lintels, etc.	Ashlar	Small Cornices, etc.
Masons	30	12	20
Laborers	30	20	30

Using Hand Derrick

Masons	24	10	15
Laborers	24	20	30

Using Power Derrick

	Heavy Foundation Stone	Thin Ashlar	Ornamental Work
Masons	4	8	12
Laborers	32	48	36
Engineer	4	4	4

Note.—The figures for power derrick do not include the cost of installing and removing the derrick, which must be figured as will be explained later.

staining mortar, the composition of which is usually definitely specified by the architect. It is becoming customary to use White Portland Cement as the binding principal in non-staining mortars and when this is done, the tables given in the chapter on brick-work can be used in figuring the cost of the mortar, taking due account of the fact that the price of white cement is very much higher than that of the standard grey color.

The quantity of mortar required can be calculated from Table XXVI.

Beside the cost of hauling, labor, elevating and mortar, it is necessary to include the cost of all anchors and clamps that are specified, being careful to note the number and kind as well as the material of which they are to be made and to get proper prices for them.

After the setting has been completed it will be necessary

TABLE XXVI.—MORTAR REQUIRED

(Cubic yards Mortar per 100 cubic feet stone)

	Setting	Pointing	Parging
Heavy foundation stone	0.10	0.03	.....
Thin ashlar work	0.15	0.05	0.15
Sills, lintels, etc	0.15	0.05	0.15
Small ornamental work	0.13	0.04	0.13
Large ornamental work	0.13	0.04	0.13

to wash the work down, using no acid for most stones, and the cost of such cleaning is to be calculated as follows:

TABLE XXVII.—CLEANING AND POINTING

	Washing Down New Work	Pointing New Work	Cleaning Old Work	Pointing Old Work
Mason	2	2	3	3
Laborer	1	1	1.5	1.5

On work which has been exposed to weather for many years, particularly in communities where much soft coal is used, an ordinary washing down, even with a strongly alkaline wash, will not restore the stone to a satisfactory appearance.

It is then necessary to report to the use of a sandblast and the work is usually done by "stone-renovators" rather than by builders.

Example I.—Assuming for example a building front, to have a granite grade-course and a limestone-ashlar facing with the usual amount of ornamental work, such as pilasters, caps, bases, cornices, etc.

The bill of quantities, using the method mentioned in the discussion of architectural terra-cotta, and taking the "squared" dimensions of all members, is assumed as follows:

	Cubic Feet
Granite grade course	120
Limestone ashlar	720
Sills and lintels	150
Ornamental features	600
Total	1,590

Assume that the stone is to be delivered f.o.b. cars at the railroad station, one mile from the job over good hard roads, there is ample room at the work to pile the stone, but as the building is three stories high, it will be necessary to hoist our stones by a power derrick which will be located at a point that will serve the entire front and obviate the necessity for re-locating during the work.

To calculate the cost of bringing the stone from the railroad to the building, use the following table:

TABLE XXVIII.—WEIGHTS OF BUILDING STONES

	Pounds per Cubic Feet
Granite	170
Limestone	137
Sandstone	164
Bluestone	151
Marble	168
Gneiss	168
Slate	175

The total weight is, therefore:

120 cubic feet granite @ 170 pounds	20,400
1,470 cubic feet limestone @ 137 pounds	201,390
Total	221,790

Since we can handle 6,000 pounds to the load it follows that we shall have to haul 37 loads, which, at 2 miles per hour loaded and 3 miles per hour unloaded will require 50 minutes per load travelling time or practically . . . . . 31 hours
to which must be added the time for loading and unloading. Allowing two men, and the driver, at the car, we find the loading time, from Table XXIV to be. . . . . 21.2 hours
and for unloading, using the derrick and the same number of men, the time will be . . . . . 13.25 hours

65.45 hours

The cost of the drivers' time is included with the cost of the team, so it is only necessary to figure the cost of the other two men, or two-thirds of the time indicated in the table, thus:

Loading 1,590 cubic feet by 4 hours per 100 by 2–3	42.4
Unloading 1,590 cubic feet by 2½ hours per 100 by 2–3	26.5
Total	68.9

assuming that enough teams are employed to keep the men busy.

The cost of the derrick engineer will be included in the cost of setting and need not be figured separately.

From Table XXV, we learn that the time required for setting the stone will be:

Ashlar Work, including sills, grade course, etc., 990 cubic feet

	hours
Mason @ 8 hours per 100 cubic feet	79.2
Laborers @ 48 hours per 100 cubic feet	475.2
Engineer @ 4 hours per 100 cubic feet	39.6

Ornamental Work, 600 cubic feet

Mason @ 12 hours per 100 cubic feet	72
Laborers @ 36 hours per 100 cubic feet	216
Engineer @ 6 hours per 100 cubic feet	36

Cleaning and Pointing 1,800 Square Feet
(from Table XXVII)

Mason @ 4 hours per 100 square feet	72
Laborers @ 2 hours per 100 square feet	36
Pole staging laborers	15

SUMMARIZING

	hours	
Teams 65.5 hours @ $1		$ 65.60
Laborers, unloading, etc	68.9	
Setting ashlar	475.2	
Setting ornament	216	
Cleaning and pointing	36	
Staging	15	
	811.1	
say 811 hours @$ .45		364.95
Masons, setting ashlar	79.2	
Setting ornament	72	
Cleaning and pointing	72	
	223.2	
say 223 hours @$ .90		200.70
Engineer on ashlar	39.6	
On ornament	36	
	75.6	
say 76 hours @$ .90		68.40
Total direct labor cost		$699.55

which equals .436 per cubic foot

Example II.—If this job could be set by hand, using a breast derrick and working from the floors as the building goes up, the cost should be figured as follows:

	hours
The time of the teams in transit would be	31
and at the car	21.2
the same as before, but their time at the building would be increased (see Table XXIV) to	21.2
Total team time	73.4
The laborers' time at the car would be	42.4
as before, but the unloading time at the building would also be	42.4
and it is necessary to allow for time needed in putting stones onto the elevator and taking them off at the upper stories. Assuming 360 cubic feet of stone to go on the first floor, we have 1,230 feet to raise to the upper stories and the distance to handle it will be taken as 100 feet, therefore, 1,230 feet @ 3 hours per 100	36.9
Total for these items	121.7

The time required for setting, from Table XXV will be as follows:

	Masons' hours	Laborers' hours
270 cubic feet sills, lintels, grade course, etc	81	81
720 cubic feet ashlar	72	144
600 cubic feet ornament	90	180
Totals	243	405

The cost of cleaning and pointing will be as before, as also will the scaffolding, summarizing we got,

Teams 73.4 hours @ $1		$ 73.40
	hours	
Laborers, unloading	121.7	
Setting	405	
Cleaning and pointing	36	
Staging	15	
	577.7	
say 578 hours @$ .45		260.10

Masons, setting	243		
Cleaning and pointing	72		
	315	@$ .90	283.50
Engineer, 16 hours on elevator, @ .90			14.40
Total direct labor			$631.40

which equals 39.7 cents per cubic feet.

Without going into the matter of rental expense on the derrick and power, or the elevator, it can readily be seen that the stone-work on the building under consideration can be handled to better advantage with a hand-derrick than with a power-derrick.

This is not an invariable rule, yet it is not at all unusual for a job of this size, as the economy resulting from power equipment does not become effective until much larger quantities of stone are handled.

In *Engineering News-Record* of March 13, 1919, I described an instance where we completed some heavy repair work on a stone dam for less than $4,000 with a hand derrick, though the estimates of our competitors, who contemplated the use of power equipment, ran as high as $39,000.00

That was an exceptional instance. It happened during a period of coal shortage, the nearest railroad was over 2 miles away and the conditions and the site were such that the cost of installing a steam-engine would have been equal to the total cost of operating the hand-derrick.

CHAPTER V

FIREPROOFING AND FIREPROOF CONSTRUCTION

SECTION I. GENERAL

Fireproof construction, or more properly speaking fire-resistive construction, divides itself into three general types; terra-cotta, gypsum and concrete.

Brickwork is, of course, a form of fire-resistive construction, in fact, it is the best known form, and also the most effective form of terra-cotta fire-resistive construction.

Terra-cotta and gypsum constructions are largely used for walls, floors, partitions and roofs and are usually placed by masons.

Concrete fireproofing is, however, usually placed by laborers, and since the same general methods apply as for other forms of concrete work, it will be more fully discussed in Chapter VI.

Hollow-tile Fireproofing.—The term fireproofing, as here used, includes all those forms of hollow terra-cotta building material that are commonly used, such as, flat and segmental floor-arches, roof-arches, "book" tile, beam-, girder- and column-covering, wall and partition tile, furring tile.

In taking off quantities of tile required for any piece of work it is necessary to make some allowance for breakage in handling and in cutting to fit around openings, against jambs, etc. It is impossible to lay down any exact rules for figuring the breakage, it may vary all the way from 1 to 10 per cent but a good method is to allow 3 per cent breakage for areas having no openings, no deductions for openings under ten square feet, one-half of openings from ten to twenty-one square feet, deduct full opening, if over

twenty-one square feet, and add enough tile to go once around the opening.

Practically all forms of hollow-tile fireproofing can be figured and bought by the square foot or by the piece. In buying by the piece, only one 12 by 12 tile is required, no matter what the thickness, per square foot but one and one-half tiles, are required of the 8 by 12 size.

"Book" tile, which are used for roofs where no heavy loads are to be carried, and are so called because their "tongue and groove" cross-section makes them resemble large books, usually come in 12 by 24 size, so that each title will lay two square feet. They are placed upon a structural steel frame consisting of angles and tees, and therefore no form work or centering is required.

Furring tile usually come in the "split" form, *i.e.*, a block resembling a partition block which is scored in such a manner that it can readily be split into two-halves, each of which is a furring tile.

Figuring Flat Arches.—When figuring flat or segmental arches for estimating purposes, it is sufficient to take from the plans the number of square feet to be covered but, when listing tile for shipment to the work, it is necessary to compute carefully the number of skewbacks, key blocks, voussoirs, soffit tile, girder shoes, etc., that will be required.

The literature issued by the manufacturers of terra-cotta fireproofing contains such a wealth of information on that subject that it is unnecessary to encumber these pages with a repetition of it.

However, it is essential that care should be taken to figure upon exactly the kinds of tile in each case that the specifications require; dense, porous or semi-porous, smooth-faced, scored, etc.

In earlier chapters we have discussed very thoroughly the cost of hauling and, knowing the weight of the various kinds of tiles likely to be used, it is a simple matter to determine the number that can be handled in a load.

The cost of loading and unloading is not so simple a matter, since there is such a variety of weights to be con-

sidered and since it is possible for a man to handle a tile weighing thirty pounds about as quickly as one weighing twenty pounds.

TABLE XXIX.—WEIGHTS OF HOLLOW-TILE

	Partitions Pounds per Block	Book-tile Pounds per Square Foot
2 by 12 by 12	12	12
3 by 12 by 12	14	14
4 by 12 by 12	16	18
5 by 12 by 12	19	.....
6 by 12 by 12	22	.....
7 by 12 by 12	25	.....
8 by 12 by 12	30	.....
9 by 12 by 12	33	.....
10 by 12 by 12	35	.....
12 by 12 by 12	40	.....

FLOOR CONSTRUCTION (POUNDS PER SQUARE FOOT)

Thickness (inches)	Segmental	End Construction, Flat	Side Construction, Flat
6	27	.....	27
8	33	27	29
9	.....	31	36
10	.....	33	39
12	.....	38	44

Note.—Prices of hollow tile are often quoted on the ton basis. From the figures given above it is then possible to determine the square-foot price of any size.

The following tables provide the necessary data for estimating loading and unloading costs, hauling, etc.

Split furring tile weigh the same per *block* as a partition block of twice the thickness.

However, the weights given in the table are average or

TABLE XXX.—LABOR COSTS OF LOADING, UNLOADING AND HANDLING HOLLOW TILE

General:		
A tile barrow load is approximately	250	pounds
A hod load is approximately	75	pounds
A man wheeling loaded barrow moves	100	feet per minute
A man wheeling unloaded barrow moves	110	feet per minute
A man carrying loaded hod moves	85	feet per minute
A man carrying empty hod moves	100	feet per minute

LOADING BARROWS FROM PILE OR UNLOADING BARROWS TO FLOOR OR SCAFFOLD

(Labor hours per 100 square feet)

Thickness in Inches	(1) Partitions	(2) Floor Tile
3	0.70	.....
4	0.75	.....
5	0.80	.....
6	0.83	0.90
7	0.85	0.95
8	0.95	1
9	1	1.10
10	1.10	1.15
12	1.25	1.30

standard weights and may vary appreciably in different localities. Care should therefore be taken to determine whether these weights apply when buying fire-proofing by weight.

The cost of building scaffolds for partition work can be determined on the basis of one scaffold builder for each four masons; and for wall-furring, one scaffold builder for each three masons.

The cost of making and handling the mortar is, of course, the same as for the same grade of mortar when used for brickwork.

Note.—The best results in hollow-tile construction are obtained with a strong cement mortar to which enough lime-putty has been added to make it spead very freely. This works better than a lime and cement mortar made in the ordinary way.

TABLE XXXI.—LAYING HOLLOW TILE

(Hours of Masons' time per 100 square feet)

Inches	Partitions	Furring	Segmental Arches	Flat Arches
2	4	3	.....	.....
3	4.5	4	.....	.....
4	4.5	.....	.....	.....
5	4.5	.....	.....	.....
6	5	.....	3	4
7	5	.....	3	4
8	5.5	.....	4	5
9	6	.....	4	5
10	6.5	.....	5	6
11	7	.....	6	7
12	7	.....	6	7

Note.—The time given for partition work is based upon 12 by 12 tiles. Where 8 by 12 tiles are used it will require 25 per cent more time to lay the same number of square feet.

In figuring costs it is necessary to include scaffold-building, mortar making, tending, and, for floor systems, building forms or "centering" and removing forms.

Where metal strips, or other forms of ties are specified in partition work, add one hour of masons' time per 100 square feet.

Where nails must be driven into brick walls to act as anchors for furring add four hours of mason's time per 100 nails, which will usually be spaced about 25 nails to the 100 square feet of furring.

TABLE XXXII.—HOLLOW TILE SPECIALTIES

(Hours of masons' time)

Inches	Per 100 Square Feet		Per 100 Linear Feet	
	Round Col. Covering	Square Col. Covering	Soffit Tile	Shoe Tile
2	2	2.5	.....	.....
3	2.5	3	.....	.....
4	3	3.5	.....	.....
.....	.....	.....	1.5	1.5

In some localities it is practicable to have the laborers set the soffit tiles under the beams when putting up the forms but bricklayers are inclined to object to the practice.

Note.—Where "lip" skewbacks are not used, one soffit tile will be required for each linear foot of steel beams.

Where the girders are to be fireproofed it will usually require two shoe tiles, or girder tiles, and one soffit tile for each linear foot of girder.

Beside that, when the girders extend more than three inches below the bottoms of the beams, it will be necessary

to figure upon sufficient partition tile, or hollow bricks to fill the space between the top of the shoe tile and the under side of the floor construction.

TABLE XXXIII.—MORTAR REQUIRED

(Cubic yards per 100 square feet)

Inches	Furring	Partitions, Col. Covering, Book Tile	Floor Construction
2	.07	.10	.....
3	.09	.12	.....
4	.....	.14	.....
5	.....	.15	.....
6	.....	.17	.17
7	.....	.20	.20
8	.....	.23	.23
9	.....	.26	.26
10	.....	.29	.29
11	.....	.33	.33
12	.....	.36	.36

This table is figured upon the basis of an average thickness of joints of ½ inch. It would be possible to construct a table giving the amount of mortar for any thickness of joints but, since the edges of the tiles are seldom straight, it is not practicable to maintain an exactly even joint and this table is, therefore, as nearly correct as working conditions warrant.

Load-bearing tiles are used for outside wall construction as well as bearing partition construction, to take the place of brickwork. They are usually faced on the outside by stucco but sometimes smooth-faced blocks are used that require no other finish.

The cost of handling these tiles, except mason's time in

TABLE XXXIV.—LOAD BEARING TILE

Size	Weight per Square Foot	Hours of Masons' Time per 100 Square Feet	Cubic Yards Mortar per 100 Square Feet
6 by 12 by 12	29	6	.26
8 by 12 by 12	34	7	.30
10 by 12 by 12	40	7.5	.38
12 by 12 by 12	52	8	.45

laying, may be calculated from Table XXX by increasing the times given for partitions by ten per cent.

Interlocking tiles, of the Denison patented type, have

TABLE XXXV.—INTERLOCKING WALL TILE

(Weight of 1 tile = 17 pounds. Corner tiles, 2 required for each linear foot of corner. Jamb tiles, 1 required for each linear foot of jamb. Bonding tiles, 0.7 inch for each square foot of 16-inch wall.)

Thickness	Quantities per 100 Square Feet of Wall			
	Tiles	Bonding Tiles	Cubic Yards Mortar	Hours Masons' Time
8-inch tile wall	210	.....	.30	9
8-inch backing to brick wall	180	.....	.25	8.5
12-inch tile wall	320	.....	.45	14
16-inch tile wall	400	70	.63	21
21-inch tile wall	530	.....	.75	24

come into very general use and are now made by licensees in many parts of the country. These licensees are glad to furnish much more detailed information as to the use of interlocking tiles than is given here but Table XXXV gives all of the necessary information for figuring the cost of handling and laying.

For each linear foot of jambs or corners, add 0.10 hour masons' time.

Figure cost of handling, unloading, etc., in the same manner as for an equal number of 4-inch partition blocks.

Note.—The time for foremen on all hollow-tile work should be figured by the method previously indicated in connection with brickwork.

SECTION II. FORMS OR CENTERING

In fireproofing the term "centering" is probably in more general use than is the term "forms," though both have practically the same meaning.

However, for hollow-tile floor arches, of all types, it is most usual to use forms which are merely assembled from 2-inch scaffold-planks and "stringers," hung from the steel floor framing by means of adjustable wrought-iron hangers. The work is usually done by laborers.

For combination hollow-tile and concrete construction, it is usual to build up the form of planking which, because of the longer spans used, must be supported at regular intervals by "shores" or posts. The work may be done either by carpenters or handy laborers.

For reinforced concrete or cast-in-place gypsum construction, it is usual to build a tightly constructed form of boards, supported by joists, posts, or other members as may be necessary. This work is almost invariably done by carpenters.

Centering for Hollow-Tile Arches.—Centering for flat-arches is a very simple form of construction, particularly where the ceiling surface is kept level and carried on the line formed by the under surface of the skewbacks.

Stringers, usually built of two pieces of 2 by 6 timber,

separated by 1 inch blocking at fairly close intervals are usually used, though some builders use single stringers.

The stringers are hung from the beams by wrought iron hangers, ¾ inch round rods being used, which are fitted with clips to attach to the upper flanges of the beams. Adjustment in length of the hangers is provided by a screw thread and nut at the top.

Scaffold planks are then laid across the stringers to form the surface upon which the tiles are laid and which supports the tiles until the mortar in the joints has set and the arches become self-supporting.

When the specifications require that the arches must be cambered (usually the amount will not exceed ½ inch), additional stringers must be provided over the tops of the beams and the lower hangers supported at the center of the span. Then the skewbacks or soffit tiles can be set at the beams, and the hangers drawn up in the middle so as to give the required camber. This is termed "center-hung centering."

Centering for segmental arches is made as for flat arches but, in addition, arch forms consisting of segmental ribs, cut to proper cross-section, and covered with 1 inch strips, are placed on top of the planking in order to give the curved shape to the arch.

As it is customary in steel-framed buildings to keep the spans between beams as uniform as possible, very little cutting of the lumber is necessary and it should be possible to use all of the lumber over at least four times.

The figures in the table are the amount of lumber needed for one time, the cost of the material actually used will be found by dividing the quantity given by the number of times it can actually be used.

This number cannot be determined without knowing the conditions under which the work is to be done.

For instance, in building a four-story building and pushing the work with any speed at all, the builder would probably put in enough forms for the first and second floors. Then the first floor forms would be re-used on the

third floor and roof, the second-floor forms would be reused on the fourth floor. This is an average use of 2½ times.

If he had no further use for them as centering, he could then credit the planks to the job at their depreciated value as second-hand scaffold-planks and the stringers as so much wood.

On the other hand, if he were constantly installing hollow-tile arches, the stringers should have a very long life, and the depreciation chargeable to any particular contract would be very small.

The hangers should last indefinitely, so it is entirely a matter of judgment as to what proportion of their cost should be charged to any job.

When using Table XXXVI it is necessary first to figure the cost of getting the lumber to the site of the work, unless it is bought delivered on the job.

TABLE XXXVI.—CENTERING FOR HOLLOW TILE ARCHES

(Per 100 square feet)

	Segmental Arches	Flat Arches		Add for Raised Skewbacks
		Center Hung	Side Hung	
FBM timber	80	100	80	20
FBM plank	80	210	210	.....
FBM boards	145	.....	.....	.....
Hours, laborers	5	5	4.5	0.5
Hours, carpenters	2.5	.....	.....	.....

The time given for laborers includes that taken for removing the forms after use.

The time given for carpenters is that required for cutting out the arch-ribs and attaching the "lagging."

SECTION III. GYPSUM FIREPROOFING

In general, the laying of pre-cast gypsum fireproofing, such as solid or hollow partitions, furring, etc., is an operation very similar to the laying of corresponding shapes of terra-cotta hollow-tile, but the work will ordinarily proceed much more rapidly because the nature of the material, as well as its lighter weight makes practicable the use of much larger units and the partition tiles are usually made 12 by 30 inches, so that 2½ square feet of partition can be laid at one operation.

Another reason why faster work can be done with gypsum fireproofing is the much more regular shape of the units. Being cast, and not burned, gypsum partitions are not subject to any shrinking or warping that will draw them from their intended shapes.

Greater Speed with Gypsum.—Because of the greater speed of laying, more scaffold men will be required to keep the same number of bricklayers busy that would be the case with hollow tile and an average of one scaffold builder for each mason is a fair basis for figuring.

The cost of handling gypsum partitions may be figured on the basis of the notes at the head of Table XXX and by substituting the figures in column 3 of Table XXXVII for those in column 1 of Table XXX.

The cost of laying and the amount of mortar required can be determined directly from the proper columns of Table XXXVII but it should be remembered that either "patent plaster" or "prepared mortar" are used with gypsum partitions. Portland cement mortar will not properly bond gypsum construction.

Table XXXVIII gives the quantities of materials needed to produce a cubic yard of mortar and the cost of mixing this mortar may be figured as explained in the discussion of brickwork.

TABLE XXXVII.—GYPSUM PARTITIONS

(1) Size	(2) Weight per Square Foot	(3) Labor Hours Loading or Unloading per 100 Square Foot	(4) Mason Hours Laying 100 Square Feet	(5) Cubic Yards Mortar per 100 Square Foot
2x12x30	7	0.50	3	.04
3x12x30	10	0.55	3	.05
4x12x30	13	0.58	3.5	.07
6x12x30	17	0.65	4.5	.10
8x12x30	23	0.70	5.5	.14

The figures in column 5 are based upon an average thickness of joints of ½ inch.

TABLE XXXVIII.—MORTAR FOR GYPSUM FIREPROOFING

Proportions	Pounds Patent Mortar	Cubic Yard Sand
1–2	1,300	0.94
1–2½	1,150	0.96
1–3	1,000	1.00

Cast-in-place gypsum constructions, as well as long-span pre-cast gypsum constructions, are essentially the products of companies specializing in those lines. Those companies make a practise of taking contracts for the complete installation of their products so no discussion of their cost is necessary here.

SECTION IV. COMBINATION HOLLOW TILE AND CONCRETE

Floor Construction.—Because the number of different types or "systems" of combination hollow-tile and concrete floor constructions is very great and because some of them are covered by patents and can only be installed by licensees under such patents, no attempt will be made to make this discussion cover every form of construction in general use. Only the "standard" types can be covered here but the same principles can be used for any other system when the details of it are known.

Such books as "Concrete Engineers' Handbook," by Hool and Johnson (McGraw-Hill Book Co.), "Useful Data," published by Corrugated Bar Co., and the literature issued by National Fireproofing Co. and other manufacturers of hollow tile, contain all of the information needed by the engineer who would determine the requisite thickness of the tiles, thickness of top-course and amount of reinforcing steel.

In Chapter VI we shall discuss the methods to be used in estimating the costs of the materials needed to make concrete of given proportions, as well as the cost of mixing that concrete and placing concrete under most of the conditions likely to be encountered in ordinary building construction.

The same principles are to be used in estimating the cost of the concrete used in combination hollow-tile and concrete construction and the quantity of concrete can readily be determined by reference to the specified requirements for thickness of tile and thickness of top-slab, if any.

Since tiles 12 inches wide, separated by a "rib" or "joist" 4 inches wide, is almost the universal type, it is evident that the joists are always 16 inches center to center and, therefore, each square foot of floor contains three-fourths the amount of concrete in one linear foot of "joist," plus the amount of concrete in a square foot of top-slab.

Thus, a construction of 6-inch tiles, with a 2-inch top-

slab, will contain the following quantities in each 100 square feet of floor.

75 6 by 12 by 12 tiles
75 linear feet 6 in.x4 in. joists = 12.5 cubic feet
top-slab (2 in.x12 in.x12 in.)x100 = 16.7

29.2 cubic feet = 1.08 cubic yards

Table XXXIX gives the concrete quantities for a variety of constructions (the tile quantity is always 75 where the width of joists is 4 inches) and the quantities for any other construction by following the method given above. In the table an allowance of 5 per cent has been made in the joists to provide for the additional concrete used at the ends of the rows of tile, over the supports.

TABLE XXXIX.—CUBIC YARDS CONCRETE PER 100 SQUARE FEET FLOOR

Construction	Concrete in Joists	Concrete in Slab	Total
4 + 2	.49	.62	1.11
4 + 2½	.49	.78	1.27
5 + 2	.61	.62	1.23
6 + 2	.73	.62	1.35
8 + 2	.97	.62	1.59
8 + 2½	.97	.78	1.75
10 + 2	1.21	.62	1.83
10 + 2½	1.21	.78	1.99
10 + 3	1.21	.93	2.14
12 + 2	1.46	.62	2.08
12 + 2½	1.46	.78	2.24
12 + 3	1.46	.93	2.39

The cost of getting the tiles into the building can be

estimated from the information given in Tables XXIX and XXX, using the columns headed "Partitions."

Placing the tiles on the forms, which can almost always be done by laborers, is an item that must not be overlooked and can be calculated from Table XL.

TABLE XL.—PLACING TILES ON FORMS

Thickness Inch	Labor Hours per 100 Square Feet
4	3
5	3
6	3.5
8	4
10	5
12	5.5

Reinforcing Steel.—Because this form of construction is not ordinarily used for heavy live-loads, it is not customary to use complicated reinforcement.

The most common method is to use one or two bars in each rib, either or both of which may be bent up at supports. Where the rods are carried across a support, care must be taken to figure in the necessary added length of rod and its weight.

The weight of the steel may be calculated by counting the number of rods, then multiplying them by their length and weight per foot or the method indicated in Table XLI.

Always add 5 per cent to the computed quantity of steel, in order to take care of waste due to cutting, bending, etc.

Because stirrups, and similar members, are not regularly used in hollow-tile and concrete constructions, the cost of forming and installing them will be fully covered in the next chapter, which takes up the entire subject of reinforced concrete work.

TABLE XLI.—REINFORCING RODS

Nominal Size Inch	Weight per Linear Foot		Pounds per 100 Square Feet	
	Round Bar	Square Bar	One Round Bar per Joist	One Square Bar per Joist
½	0.67	0.85	51	64
⅝	1.05	1.35	79	102
¾	1.52	1.91	114	143
⅞	2.06	2.64	155	198
1	2.67	3.40	200	255
1⅛	3.41	4.30	256	322
1¼	4.20	5.35	315	403

Steel in Cut Lengths.—It is the custom to purchase the steel cut to scheduled lengths so the only costs that are incurred at the site are bending and placing.

This work can just as readily be done by any handy men, after a little training, but union regulations in many sections require reinforcing steel to be placed by structural steel erectors or metal-lathers.

Table XLII gives the production that may be expected from men of ordinary skill under good supervision.

Forms.—For a "one-way" type of floor construction, open forms, similar to those used for ordinary hollow-tile floor construction, except that supporting "shores" or posts will be required, will suffice. In fact, it is only necessary that the planks should be spaced so as to come under the "joists" or ribs and to extend a sufficient distance on either side to support the tiles.

For a "two-way" construction, however, unless some

TABLE XLII.—REINFORCING STEEL

(Time in labor hours)

Bar Sizes Inch	Bending per 100 Eighth or Quarter Bends	Placing 100 Bars		
		Under 10 Feet Long	10 to 20 Feet Long	20 to 30 Feet Long
½ or under.....	1	4.50	5.75	7.
¾ and ⅞.....	1.33	5.25	6.75	8.25
1	1.67	6.25	8.	9.75
1¼ and 1⅛.....	2	7.50	9.75	11.50

form of "channel tiles" are used, it will be necessary to construct a solid floor of form work, as for a straight reinforced concrete slab.

Except for the item of forms, the instruction given here for estimating "one-way" constructions will apply for "two-way" constructions, if proper allowance is made for the difference in quantities.

A good type of form construction consists of 2 by 8 planks, one under each "joist," resting on 4 by 6 joists, supported by 4 by 4 posts. There will also be the necessary amount of bracing and bolsters and short planks, or pedestals, under the lower ends of the posts.

Table XLIII gives the necessary information for determining the number of joists and posts required, and 25 per cent should be added to the quantity thus calculated in order to take care of the bracing, bolsters and pedestals.

Salvage values are to be determined, upon the same basis as that already outlined for centering for hollow-tile construction.

TABLE XLIII.—FORM JOISTS AND POSTS

Construction	Spacing of Joists in Inches	Spacing of Posts in Inches
4 + 2	58	72
4 + 2½	58	72
5 + 2	56	66
5 + 2½	56	66
6 + 2	56	66
8 + 2	52	60
8 + 2½	52	60
10 + 2	50	54
10 + 2½	50	54
10 + 3	50	54
12 + 2	48	48
12 + 2½	48	48
12 + 3	48	48

Example.—Thus, to support a floor construction consisting of 10-inch tile and 4-inch by 10-inch concrete joists with a 2½-inch top, over an area 25 by 100 feet, would necessitate the use of the following form lumber, the clear story height being assumed as 12 feet:

	FBM
Planks (25-foot length not being a stock length in most places, we must use a 14-foot and a 12-foot length).	
2x8: 75 pieces-12 feet, 75 pieces-14 feet	2,600
Joists (25 feet divided by 50 inches plus 1 joist) = 7 rows.	
4x6: 35 pieces, 20 feet long	1,400
Posts (7 rows joists, 100 feet long, 1 post each 54 inches, plus 1 post in each row) = 161 posts.	
4x4: 161 pieces, 12 feet long	2,576
Braces, etc. (25 per cent of joists and posts)	944
	7,520

which equals practically 3 FBM per square foot of floor construction.

The total time required for handling this material, after delivery to the site, may be calculated from Table XLIV. The time is given there in labor hours, to be divided by the estimator among carpenters and laborers as local conditions may require, but the work is not beyond the skill of good laborers.

TABLE XLIV.—LABOR ON FORMS

Assembling and erecting	15 hours per 1,000 FBM
Stripping	6 hours per 1,000 FBM
Re-erecting	11 hours per 1,000 FBM

CHAPTER VI

PLAIN AND REINFORCED CONCRETE WORK

SECTION I. GENERAL

It was the intention in writing this text, in so far as it is practicable to do so, to make each of the chapters complete in itself. However, there is hardly an operation in general building construction that is so unique that much that may be said of another operation will not apply to it as well.

For this reason, it will often be necessary for a student to master several different chapters before he will become really proficient in estimating the class of work covered by any one of them.

For instance, while this present discussion of the method of estimating the cost of concrete work will be rather lengthy, the student must also thoroughly master the chapters on excavating, brickwork, and timber framing, if he would get the best results in this particular work.

It is well to adopt a uniform procedure when listing quantities for any kind of work, particularly so for concrete work.

The best method is to start at the beginning and list the different items in approximately the same order in which they will be constructed, thus: wall-footing, pier-footings, walls, piers, etc. Also to follow a regular system of setting down the dimensions, *viz.*, length first, width or thickness second, and height third.

This method will always make it practicable to know just what each figure means and will also facilitate the calculation of form quantities.

Formwork Important.—It hardly seems necessary, at this late date in concrete construction, to stress the importance of carefully figuring all formwork, either by the number of square feet of contact area or by the number of board feet of lumber to be used, and not by lumping the cost of formwork into the cost of a cubic yard of concrete.

As a general rule the contact area method is used because it gives very close results and is sufficiently accurate for all ordinary kinds of construction. For unusual work that would involve difficult, extra strong or intricate formwork, the design of the forms should be worked out before estimating and the cost carefully computed on the basis of the material to be used and the work to be done.

Calculation of the quantities of materials required to produce a cubic yard of concrete has now been reduced to the simple operation of referring to a table. Numerous such tables in many varying forms, have been published, but the one which appears below is sufficiently complete

TABLE XLV.—QUANTITIES OF MATERIALS REQUIRED TO PRODUCE ONE CUBIC YARD OF CONCRETE IN PLACE

(In each column, the quantities appear in the following order: Barrels, cement, cubic yards sand, cubic yards gravel or stone)

Nominal Proportions	1-Inch Stone and Under (Dust Screened Out)			2½-Inch Stone and Under (Dust Screened Out)			2½-Inch Stone and Under (Most Small Stone)			¾-Inch Gravel and Under (Sand Screened Out)		
1–2–4	1.46	0.44	0.89	1.48	0.45	0.90	1.53	0.47	0.93	1.34	0.41	0.81
1–2½–5	1.19	0.46	0.91	1.21	0.46	0.92	1.26	0.48	0.96	1.10	0.42	0.83
1–3–5	1.11	0.51	0.85	1.14	0.52	0.87	1.17	0.54	0.89	1.03	0.47	0.78
1–3–6	1.01	0.46	0.92	1.02	0.47	0.93	1.06	0.48	0.97	0.92	0.42	0.84
1–3–7	0.91	0.42	0.97	0.92	0.42	0.98	0.94	0.42	1.05	0.84	0.38	0.89
1–4–7	0.83	0.51	0.89	0.84	0.51	0.90	0.87	0.53	0.93	0.77	0.47	0.81

for all ordinary uses. Most of the cement companies publish similar tables in handy pocket "calculator" form and are glad to furnish them without cost to people having need of them.

This is about as wide a range of proportions as is found in ordinary building work, except cement finish work, which is covered in a later section but in reinforced concrete work it is often necessary to use much richer mixtures in columns or other places where great compressive strength is required.

Portland cement is generally sold by the barrel, practically 3.8 cubic feet, and it is usually delivered in cloth sacks holding one-quarter barrel each. Delivery is sometimes made in paper bags of the same size, less frequently in wooden barrels, and occasionally in bulk car-loads.

Sand, gravel and crushed stone may be sold either by the cubic yard or by the ton. Since the quantity of material to be used will be figured on the cubic yard basis, prices per ton should always be converted to prices per cubic yard.

It is always advisable to obtain the correct weight per cubic yard of any material which is proposed to use, but

TABLE XLVI.—WEIGHTS OF CONCRETE MATERIALS

	Pounds per Cubic Yard
Sand	2,700
Gravel	2,700
¾-inch crushed trap rock	2,600
1½-inch crushed trap rock	2,550
1½-inch crushed limestone	2,360
¾-inch crushed granite	2,500
1½-inch crushed granite	2,400
Crushed slag	2,000

in the absence of more definite information the following weights may be used.

When figuring upon slag-concrete, as a substitute for stone- or gravel-concrete, it is necessary to keep in mind the fact that you will probably need at least one-fourth more mortar in your mixture than you would to get a concrete of the same consistency with stone or gravel.

SECTION II. HAULING AND HANDLING MATERIALS

Whenever possible, it is well to get prices on all materials delivered directly to the site of the work. However, this is not always possible and the information given here, as well as that contained in the chapters on excavating and on brickwork, will enable an estimator to figure his own delivery costs.

A bag of cement weighs 96 pounds (for convenience in estimating it will be considered as 100 pounds), therefore, the load handled by a two-horse team will be about as follows:

TABLE XLVII.—HAULING CEMENT

On poor earth roads...	2,000 pounds =	5	barrels cement
On fair earth roads....	2,500 pounds =	6¼	barrels cement
On good earth roads...	4,000 pounds =	10	barrels cement
On hard surfaced roads	6,000 pounds =	15	barrels cement

On level grades, the rate of travel will be 2 miles per hour with the load and 3 miles per hour with the empty wagon.

In figuring on the use of a motor truck, it can be considered that it will carry its rated load and the speed will vary from 8 miles per hour for poor roads up to 12 miles per hour for good roads. Trucks can operate at greater speeds and can carry more than their rated loads, but this is only at a greatly increased cost of maintenance.

The time required for loading and the labor cost o loading, can be figured as follows:

From box car onto wagon, about 1 minute laborer' time per bag.

From ordinary cement shed onto wagon, 1¼ minut of laborer's time per bag.

Loading and Unloading Time.—Thus, with three me working, a load of 15 barrels (60 bags) will require th wagon to stand for 20 minutes if loaded from the ca and 25 minutes if loaded from the shed. If the force i larger, the time will be reduced proportionately.

Unloading will require ¾ minute of laborer's time pe bag if placed on a pile and 1¼ minutes if placed in the shed

In figuring the cost of cement do not forget to mak allowance for the bags. Cloth bags are usually charged a 10 cents each and credited at the same price when re turned, charges prepaid, in good condition to the cemen company's mill.

Since there is no way of knowing in advance how man bags will be lost or damaged on the work, it is good prac tice to figure on a loss of one bag out of each four; thi figure also to take care of the cost of return freight an handling charges. Paper bags or wooden barrels are no returnable for credit.

When sand or gravel must be obtained directly fro the bank, the cost of obtaining it can be figured as ex plained in the chapter on excavating and due allowanc must be made for the cost of stripping off loam or othe worthless material.

The bank should be visited and as careful a computatio as is practicable under the circumstances should be mad of the quantity of material to be stripped off and this co divided over the cost of the quantity of usable materia required from the bank.

It will seldom be practicable to use a "bank-run" mixtu of sand and gravel in concrete, but will usually be necessa to screen it to separate sand and gravel. Where it practicable to set up the hand-screen at the bank, a

allowance of 35 minutes of laborer's time will be sufficient for each cubic yard of the bank-run material.

The proportion of sand and gravel that any bank will produce can only be determined by test, and such a test should always be made when estimating on important work.

A word of caution may be added here. Quite frequently a bank of sand may be entirely suitable for concrete as far as may be determined by visual examination, yet a chemical analysis or a test of a sample of concrete made from the sand may disclose the presence of vegetable acids or other impurities that would make the sand unsafe for use. It is well to investigate this feature thoroughly when estimating.

Sand in Carloads.—When sand, gravel or broken stone is purchased in carload quantities the following figures will govern: Cost of carting from car to the work must be figured as previously explained and added to these costs. These figures are also to be used in computing the cost of moving material from a sand or gravel bank to the work.

Figures are given in hours of labor time, the waiting time of the wagon will be determined by its capacity and the number of men employed in loading. The waste time of

TABLE XLVII*a*.—LOADING MATERIALS PER CUBIC YARD

(Time in labor hours.)

	From Ground to Wagon		From Gondola Car to Wagon	
	Wet	Dry	Wet	Dry
Sand	0.50	0.34	0.45	0.3
Gravel	0.65	0.47	0.60	0.4
Crushed trap-rock	.....	0.51	.....	0.44
Crushed granite	.....	0.49	.....	0.42

the men will be determined by the number of wagons employed and their headway interval.

Lost time of men and wagons may be reduced to a minimum by the use of unloading boxes, which are hung on the side of the car and into which the material is shovelled. When a wagon is to be loaded it is driven under the box, the contents dumped into the wagon, the wagon driven away and the box made ready to receive the load for the next wagon.

The student who desires to pursue the study of mechanical methods of handling concrete materials will find much valuable and interesting material in Gillette's "Handbook of Construction Cost."

SECTION III. MIXING AND PLACING

Now-a-days, very little concrete in building work is mixed by hand, the usual practice being to use a gasoline machine-driven mixer. Steam mixers are used in some cases but they are coming into disfavor because of the need of having a skilled man—in many States he must be licensed—to take charge of the boiler and engine.

Electric motor-driven mixers are also used at times, but they have not attained any great vogue.

Whether the mixing be done by machine or by hand, it must always be remembered that the number of yards of material fed into the mixer or onto the board will always greatly exceed the number of yards of concrete taken out.

For instance, 1-3-6 mixture, using 2½-inch stone and under with the dust screened out, will require for each cubic yard of concrete:

0.93 cubic yard stone
0.47 cubic yard sand
0.15 cubic yard cement

Total.. 1.55 cubic yards material

which is the quantity that must be handled from stock-pile or cement-shed to the mixer.

Since this is dry material, the following figures may be used: One laborer can handle and move any of the following quantities of materials a distance of 40 feet in 1 hour:

1.65 cubic yards sand or gravel
1.71 cubic yards crushed traprock
1.93 cubic yards crushed limestone
1.78 cubic yards crushed granite
2.22 cubic yards crushed slag
40 bags portland cement

When the mixing is by machine, it is necessary to know the capacity of the mixer in cubic yards per hour for average running and the daily charge or rental rate of the mixer, as well as its consumption of fuel per day or hour.

Sometimes the capacity of a mixer is limited by a clause in the specifications which requires that the concrete be mixed for a given number of minutes before discharging, but usually the time of the mixer is determined by the ability of the machine to deliver well-mixed product.

There are many records quoted ranging from a batch a minute upward, but it is hardly safe to figure on better than an average of fifteen batches per hour for the usual run of concrete work in building.

Thus, if the mixer is a "one-bag" size it will turn out fifteen batches of 6.42 cubic feet of mixed concrete each (10 cubic feet in-put each) when working on a 1-3-6 mixture, using 2½ inches and under stone with dust screened out. This equals 3.57 cubic yards of concrete.

From the mixer, the laborers can each receive an average of 35 cubic feet per hour and wheel it a distance of 40 feet and dump it into the forms.

In addition to the number of men required to put the materials into the mixer and take the concrete away, allowance must be made for one man to tend the mixer, untie cement bags, etc., and at least one man to puddle the concrete into the forms.

With each increase of one bag in the nominal capacity of the mixer, one additional man will be needed for pud-

dling and helping to dump concrete and one extra man to assist around the mixer.

All of these statements apply to average conditions. When estimating careful attention must be given to all details to determine whether less favorable or more favorable conditions are likely to be encountered.

If the actual mixing is to be done by hand an allowance of 1.25 hours labor time must be included for each cubic yard of concrete. This covers the cost of doing the work that is done in the mixer and also the work done by the men tending the mixer.

To all of the above figures must be added the cost of a foreman and a water boy. Their cost per cubic yard is found by determining the average production of the plant contemplated for the job under consideration.

Cost of Water.—The cost of water for mixing, while a small item, must always be included in the estimate, as well as the cost of connecting with the supply. Some cities make a flat charge per cubic yard of concrete, others require that the supply be metered and payment made accordingly. About 26 gallons of water are required for mixing a yard of concrete but, including wastes, water used for sprinkling and other purposes, the actual quantity used on the job will be more nearly 100 gallons per cubic yard.

After the concrete has set and the forms are removed, it is usually necessary to smooth all exposed surfaces, erase form-board marks, and fill up hollow spots. Since the cost of doing this work is entirely dependent upon the care in building the forms and placing the concrete, it is a very difficult matter to determine the cost of finishing in advance.

However, the following figures may be used for all ordinary work:

Nothing has been said thus far about the cost of building runs for wheeling concrete. For ordinary plank runs the figures already given for moving concrete will be found large enough to take care of the usual amount of placing and moving.

Where the nature of the work is such that it will be

TABLE XLVIII.—FINISHING CONCRETE SURFACES

(Square feet per hour)

	Laborers	Masons
Cement-wash	20	.....
Brush-hammer (hand-work)	.....	5
Crandalling (hand-work)	.....	5
Picking surface (screen)	12	.....
Picking surface (hand)	6	.....
Carborundum rub	7	.....

necessary to build trestles or other special forms of runs, they must be figured separately, as will be explained in the chapter on timber-framing and the section on reinforced concrete construction.

Delivery and Removal of Equipment.—Allowance must also be made for the cost of delivering equipment to the work and removing it at the completion. This is so variable a factor that it is difficult to give any rules for estimating. For instance, a small gasoline mixer may be so compact as to require practically no setting up after unloading from the car or truck, while a large steam mixer may require several days' labor in order to put it in running condition.

Cost of freighting equipment to and from the location of the work can be ascertained by inquiry of the carrier, and charges for unloading from car to truck and truck to car, or vice versa, will average about 60 labor-hours per carload.

Since the equipment must be loaded and unloaded on both trips and must be freighted back to headquarters, a fair-sized job will have to bear the expense of 240 hours' loading and unloading labor, trucking costs at both ends, both times, and freight two ways.

When cement is to be stored at the work, sheds must be built for this purpose and, having determined the size necessary on the basis of the maximum amount to be stored, the cost of the shed can be estimated in accordance with the methods outlined in the chapters on carpenter work. Credit can, of course, be taken for the salvage value of the lumber after the shed is no longer required.

SECTION IV. FORM WORK

Practically all forms for concrete work in buildings are now constructed of 1-inch boards, supported by 2 by 4 studs spaced from 12 to 24 inches apart, depending upon the height to be supported on the load to be retained. Sometimes 1½ or 2-inch plank may be used for particularly heavy work or when so specified by the architect or engineer.

Since the usual method is to use 1-inch boards, we will base our present estimates accordingly and the materials for 100 square feet of forms will be figured as follows:

	Square Feet	
Actual area of form	100	
Waste for cutting, etc	15	
	115 of	
1-inch boards or 115 feet B.M. @ $27 per 1,000		$3.11
Studs 10 pieces 2x4x10–0	67 FBM	
Allowance for waste 15 per cent	11 FBM	
	78 FBM	
78 FBM studs @ $36 per 1,000		2.81
Nails (approximately 40 pounds per 1,000 FBM), 8 pounds @ 5 cents		.40
Tie-wire (approximately 25 pounds per 1,000 FBM), 5 pounds @ 6 cents		.30
First cost of materials for 100 square feet		$6.62

The cost of labor will be governed largely by the class of men employed. For instance, if local conditions make it necessary to have practically all of the work done by car-

penters, the cost will naturally be higher than where a large part of it may be done by "handy-men."

On an ordinary job, where the laborers do all the handling of the lumber except the cutting, assembling and nailing in the building of the forms and also assist in the erection, each 100 square feet of forms, allowing an average of two FBM of material per square foot, will require the following:

TABLE XLIX.—LABOR PER 100 SQUARE FEET FORMS

	Assembling	Erecting	Total
Footings			
Carpenters' time	2½	½	3
Laborers' time	1	1	2
Foundation Walls: (first ten feet in height)			
Carpenters' time	3	1½	4½
Laborers' time	1½	1½	3
Each additional ten feet in height			
Additional carpenters' time		½	½
Additional laborers' time		1	1
Piers (Plumb Sides):			
Carpenters' time	4	1½	5½
Laborers' time	1½	1½	3
Piers (Pyramidal Types):			
Carpenters' time	5	1½	6½
Laborers' time	1½	1½	3
Steps, Lintels, etc.:			
Carpenters' time	7	2	9
Laborers' time	1½	2	3½
Slabs, Platforms, Etc.:			
Carpenters' time	6	1½	7½
Laborers' time	1½	1½	3

All of these figures are based on the assumption that the lumber will not be moved over 200 feet from stock-pile to its position in use. For greater travel add ½ hour laborers' time per 100 square feet for each additional 100 feet of travel.

After the concrete is hardened, the forms must be stripped and cleaned if they are to be re-used, or removed if they are of no further use.

For stripping, an allowance of 3 hours laborers' time per 100 square feet must be made.

When estimating the cost of forms, for any concrete work, it is necessary to determine how many times the forms may be re-used, if at all, and what value, if any, will be left in the form lumber at the end of the work.

Re-use of Concrete Forms.—If the forms can be re-used, as when there are a number of members of the same dimensions, without any rebuilding, it is only necessary to figure the cost of material and of building the first time, and then to add the cost of stripping and re-erecting as many times as the forms will be re-used.

If the forms are used only once, the lumber may have a salvage value of as high as one-third of its original cost, depending upon how much cutting up has been done, but when the forms are used more than once it is not wise to figure upon much re-sale value unless you have a certain place to dispose of the lumber.

Where the forms may be used again, but only after re-cutting and re-assembling, it is not necessary to figure for new lumber again, but a new allowance of at least 15 per cent for waste must be made and an allowance of ½ hour carpenters' time per 100 square feet must be made to compensate for the slower work on the used lumber.

A further discussion of the cost of forms and form-building will be given in the section on reinforced concrete construction.

SECTION V. SIDEWALKS, FLOORS, ETC.

We have already discussed how to estimate the cost of handling the materials for concrete and of mixing the con-

rete and delivering it to the point at which it is placed in he forms.

The same principles govern the estimating of the cost of idewalks, floors, etc., though it is usually easier to take off he quantities of sidewalks and floors by square feet, and of base, curbing, etc., by linear feet.

The following table, originally published by the author n *Concrete* for November, 1921, will facilitate the quick computation of the quantities of materials required for any loor or sidewalk job.

TABLE L.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Base Course			
		1–2–4 Mix	1–2–5 Mix	1–2½–6 Mix	1–3–6 Mix
1 in. thick	Cement	0.45	0.39	0.37	0.31
	Sand	0.34	0.12	0.14	0.14
	Aggregate	0.28	0.30	0.28	0.28
2 in. thick	Cement	0.90	0.79	0.74	0.63
	Sand	0.27	0.24	0.28	0.28
	Aggregate	0.55	0.60	0 56	0.56
3 in. thick	Cement	1.35	1.18	1.10	0.95
	Sand	0.41	0.36	0.43	0.43
	Aggregate	0.83	0.90	0.85	0.85
4 in. thick	Cement	1.80	1.57	1.47	1.26
	Sand	0.54	0.48	0.57	0.57
	Aggregate	1.10	1.20	1.13	1.13
5 in. thick	Cement	2.25	1.96	1.84	1.26
	Sand	0.68	0.61	0.71	0.71
	Aggregate	1.37	1.50	1.40	1.41

TABLE L.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.—Continued

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Base Course			
		1–2–4 Mix	1–2–5 Mix	1–2½6– Mix	1–3–6 Mix
6 in. thick	Cement	2.70	2.35	2.20	1.89
	Sand	0.82	0.73	0.86	0.85
	Aggregate	1.65	1.80	1.69	1.70
7 in. thick	Cement	3.15	2.74	2.57	2.40
	Sand	0.96	0.85	1.00	0.99
	Aggregate	1.93	2.10	1.97	1.98
8 in. thick	Cement	3.60	3.13	2.94	2.51
	Sand	1.09	0.97	1.14	1.14
	Aggregate	2.20	2.40	2.26	2.27
9 in. thick	Cement	4.05	3.52	3.30	2.83
	Sand	1.23	1.08	1.27	1.28
	Aggregate	2.47	2.70	2.54	2.55
10 in. thick	Cement	4.50	3.92	3.66	3.14
	Sand	1.37	1.21	1.41	1.58
	Aggregate	2.75	3.00	2.81	2.82
11 in. thick	Cement	4.95	4.31	4.03	3.45
	Sand	1.50	1.33	1.55	1.56
	Aggregate	3.03	3.30	3.09	3.12
12 in. thick	Cement	5.40	4.70	4.40	3.77
	Sand	1.63	1.45	1.69	1.70
	Aggregate	3.30	3.59	3.37	3.40

TABLE L.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.—Continued

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Top Course			
		1–1 Mix	1–1½ Mix	1–2 Mix	1–2½ Mix
½ in. thick	Cement	0.75	0.59	0.50	0.43
	Sand	0.12	0.14	0.15	0.16
¾ in. thick	Cement	1.12	0.89	0.75	0.64
	Sand	0.18	0.21	0.23	0.42
1 in. thick	Cement	1.50	1.19	0.99	0.85
	Sand	0.23	0.27	0.30	0.32
1½ in. thick	Cement	2.25	1.78	1.49	1.27
	Sand	0.34	0.41	0.45	0.48
2 in. thick	Cement	3.00	2.37	1.98	1.69
	Sand	0.45	0.53	0.59	0.63

		1–3 Mix	1–1–1 Mix	1–1–2 Mix
½ in. thick	Cement	0.37	0.50	0.41
	Sand	0.17	0.08	0.06
	Aggregate	.....	0.08	0.13
¾ in. thick	Cement	0.56	0.75	0.61
	Sand	0.25	0.12	0.09
	Aggregate	.....	0.12	0.19
1 in. thick	Cement	0.74	1.00	0.81
	Sand	0.33	0.15	0.13
	Aggregate	.....	0.15	0.26

TABLE L.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.—Continued

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Base Course		
		1–3 Mix	1–1–1 Mix	1–1–2 Mix
1½ in. thick	Cement	1.17	1.50	1.21
	Sand	0.50	0.22	0.19
	Aggregate	.....	0.22	0.38
2 in. thick	Cement	1.54	2.00	1.62
	Sand	0.58	0.30	0.25
	Aggregate	.....	0.30	0.50

In addition to the necessary labor of handling the materials and mixing the concrete, the following labor must be included in the estimate:

TABLE LI.—LABOR ON FLOORS AND WALLS, ETC.

	Hours
Per 100 square feet finish:	
Carpenters' setting screeds	0.4
Cement finishers	3
Per 100 linear feet plain base:	
Carpenters' setting grounds	1.5
Cement finishers	3
Per 100 linear feet sanitary base:	
Carpenters' setting grounds	1.5
Cement finishers	4.5

It is also necessary to include all of the items of mixing, heeling, hoisting, etc., that are involved.

When estimating floors or walks going on earth, it is ssential to have an item in the estimate to cover excavat-ng to the under side of the construction, and also any nder or gravel course that may be specified.

For curbing, it is necessary to include the cost of finish-g top and face, also curb-bar, if specified.

Example.—Compute the cost of a floor for an area 72 et by 201 feet, including 6 by 1-inch sanitary base all round. The floor is to consist of 4 inches of 1-2-4 base ourse and 1 inch of 1-2 top course. Distance to railroad ½ miles over hard road. Distance to sand and gravel pit ½ mile over poor road. Excavation for floor by others.

se the following prices:

Cement finishers	65 cents per hour
Concrete laborers	50 cents per hour
Concrete foreman	65 cents per hour
Carpenters	85 cents per hour
Water boy	30 cents per hour
Teams	$1 per hour
Cement in cloth	$3 per barrel, f. o. b. cars
Sand	25 cents per yard in the pit
Gravel	25 cents per yard in the pit
Water rate	5 cents per cubic yard

Area to be Covered

x201 = 14,472 square feet.

Length of Base

) x 72 = 144
) x201 = 402

546 linear feet = 273 square feet

Materials Required (From Table L)

	Barrel Cement	Yard Sand	Yards Gravel
se course	1.80	0.54	1.10
p coat	.99	0.30	....
Total per 100 square feet	2.79	.84	1.10

For floor 2.79x144.72 = 403.8		
For base 0.99x 2.73 = 5.5		
409.3 barrels cement @ $3		$1,227.90
For floor 0.84x144.72 = 121.6		
For base 0.30x 2.73 = .8		
122.4 yards sand @ $0.25		30.60
For floor 1.10x144.72 = 159.2 yards gravel @ $0.25		39.80
Water @ 5 cents per cubic yard of concrete		8.00
Total for materials		$1,306.30
Hauling (From Table XLVII)		
	Hours	
Cement, 15 barrels per load, 28 trips @ 1.25	35	
Waiting time, 28 trips @ 0.67	19	
Sand and gravel, 0.74 cubic yard per load, 380 trips @ 0.24 hours	91	
Waiting time, 380 trips @ 0.16 hours	61	
Total team time @ $1.00	206	$206.00
Laborers		
Load and unload cement, 410 barrels @ 0.06	25	
Load sand, 123 yards @ 0.50	62	
Load gravel, 160 yards @ 0.65	104	
Charge cement into mixer, 410 barrels @ 0.10	41	
Charge sand into mixer, 123 yards @ 0.61	75	
Charge gravel into mixer, 160 yards @ 0.61	98	
Attend mixer, 1,680 batches @ 0.025	42	
Spread concrete, 1,680 batches @ 0.025	42	
Wheel concrete, 160 yards @ 0.77	123	
	612 @ $ .50	$306.00

Carpenters

	Hours		
etting screeds for finish, 145 squares @ 0.4	58		
etting screeds for base, 546 linear feet @ 1.5 per 100	8.2		
	66.2	@ $ .85	$ 56.27

Finishers

	Hours		
n finish, 145 squares @ 3 hours	435		
n San. base, 546 linear feet @ 4.5 hours per 100	246		
	681	@ $ .65	$442.65

Mixer Expense

,680 batches	14 days @ $5.00	$70.00

20 per day

Foreman

4 days or	112 hours @ $0.65	$72.80

Summary

Iaterials	$1,306.30
auling	206.00
aborers	306.00
arpenters	56.27
inishers	442.65
ixer expense	70.00
oreman	72.80
surance on teams	6.18
surance on payroll	47.71
ontingencies	120.00
Cost	$2,633.91

Note.—There will be a credit against this amount for the number of gs actually returned. On a job under average conditions this credit uld be 1,227 bags @ 10 cents, or $122.70.

Instead of pursuing the method just outlined, many esti mators prefer to calculate the cost of all of the items pe square foot, or per hundred square feet, and to multiply the total area by the unit price thus obtained.

The principles and results are the same in either case and it is purely a matter of choice as to which method i used.

SECTION VI. REINFORCED CONCRETE WORK

At the outset, grateful acknowledgment is made to K R. Wagner, Secretary, George W. Stiles Construction Co Chicago, for the very kind assistance rendered by him i furnishing data and in making helpful suggestions that wer used in the preparation of this Section.

A reading of the earlier sections in this chapter and th previous chapter has conveyed a knowledge of the method to be employed in

delivering materials to the site of the work,
handling the materials to the mixer or mixing board
mixing under most ordinary circumstances,
placing concrete in forms,
building simple forms,
placing unassembled reinforcement.

It is not necessary, therefore, to make any attempt t go over the ground that has previously been covered, bu rather, as quickly as possible, to attack those problem in estimating the cost of reinforced concrete that diffe essentially from the problems encountered in estimatin the cost of plain concrete work.

Usually plain concrete building construction will be 1-3-6 or 1-2½-5 mix, but most of the reinforced work will b 1-2-4 mix, while the columns will probably be somewha richer, depending upon the loading.

Since each variation in the mixture changes the mone cost of the materials used, as well as the amount of labo involved, in handling the ingredients of a cubic yard c

concrete, each class of concrete should be figured separately.

Rules for Scaling Quantities.—The following rules be observed in scaling quantities:

Figure slabs to full over-all dimensions.
Figure beams and girders only to underside of slab.
Figure drop-heads as additions to slabs.
Figure all forms, except round columns and their splay-heads, by actual contact area.
Figure round column forms by listing the number of columns of each diameter and their lengths.
Figure reinforcing steel in pounds, by listing the quantities of each size and multiply by the weight per lin. ft. given in Table XLI, Chapter V.

Placing Reinforced Concrete.—Having determined the quantities of concrete involved, and the costs of the materials required to produce them, it is possible from what has been learned from previous chapters readily to compute the cost of assembling those materials and mixing them into concrete.

Because the quantities to be handled are ordinarily very large in reinforced concrete buildings, as compared with plain concrete work, the method and equipment used are essentially different.

Of course, on a small job, even though it should be reinforced concrete, the work to be done, if it be under 200 cubic yards, will not ordinarily warrant the use of any complicated plant and the methods used for placing plain concrete will apply; but, because of the additional care required properly to surround all steel with concrete, the cost of spreading will be practically doubled.

Of course, since the organization will be proportioned to take care of the full production of the mixer, the number of men required for spreading will be the same whether the placing be done by wheelbarrows, carts, chutes or other device.

While a man can wheel about three times as much concrete in a two-wheel cart as he can in a barrow, the lost

time in turning and the necessity for heavier and wider runs, makes it impossible to show a proportionate saving in cost.

With carts, instead of figuring that a man will move 35 cubic feet a distance of 40 feet per hour, we can assume a figure of 55 cubic feet for the same distance.

We have now only to consider the costs of elevating the concrete to be distributed by carts and the cost of handling it by elevating buckets and chutes.

Working continuously, a two barrow elevator can hoist the equivalent of 2,700 cubic feet per 1 foot per hour in barrows, or 8,000 cubic feet per 1 foot per hour in carts.

These figures may be considered the limit of capacity for a platform elevator as ordinarily operated, but in most cases the amount handled will be determined by the capacity of the mixer and the daily fixed charge for the elevator must, therefore, be distributed over the number of cubic yards of concrete produced.

Thus, if the mixer is delivering 3.5 cubic yards per hour, its production per 8-hour day would be 28 cubic yards and at a daily elevator cost of $20, the charge would be $0.714 per yard.

When chutes are used, it is possible to arrange for hoisting capacity well adjusted to the mixer capacity, so that the fixed daily cost of the chuting plant is to be divided by the number of yards delivered in order to determine the hoisting and chuting cost per yard.

If the plant is rented, or if a rental rate has been fixed for it, the problem is simple; otherwise it is necessary to calculate the cost of delivering the plant to the work, setting up, maintaining it, dismantling it and returning it to headquarters, as well as allowance for depreciation. This estimated cost is then divided by the number of yards to be placed in order to obtain the charge per yard.

Often, even though the plant is rented, the user pays all charges from the time it is loaded on cars at headquarters until it is returned there, so practically the same process must be gone through.

The cost of freight can, of course, only be ascertained by determining the weight of the equipment and inquiring of the transportation company.

The cost of hauling or trucking and unloading can be determined by methods previously outlined.

Erection and Dismantling.—The cost of erecting and dismantling a chuting plant is approximately 2 hours labor or carpenters' time per foot of height and the tower must be built high enough above the highest point at which concrete is to be deposited to allow the elevating bucket to discharge into the hopper and for the chutes to have sufficient pitch from hopper to point of deposition so that the concrete will flow properly.

This pitch is given by Hool and Johnson, in "Concrete Engineers' Handbook," as follows:

For a distributing distance of 50 feet, Pitch 1 in 6
For a distributing distance of 100 feet, Pitch 1 in 4
For a distributing distance of 300 feet, Pitch 1 in 3

Beside this, allowance must be made for the height of the swivel joints at each change of direction of a chute. All this really means that it is necessary to have the plant pretty well in mind when estimating.

SECTION VII. FORMS FOR REINFORCED CONCRETE

If it were feasible always to make a design of the formwork for a given building before submitting the estimate, it would be advisable to estimate the cost by methods similar to those given for estimating the costs of timber construction and of planking, but since it is seldom that sufficient time is available for such detailed work, it has become customary to make practically all estimates upon the basis of the area of forms in contact with concrete.

For that reason, we shall confine ourselves to a discussion of the contact area method in this Chapter, since Chapter VII contains sufficient data to enable use of the more detailed method whenever desired.

On an ordinary reinforced concrete building the forms become practically a complete structure in themselves, so it is rather difficult to determine just what portion of the lumber is chargeable to the different items of formwork, but for all ordinary purposes the data in Table LIII will be found sufficiently accurate.

However, experience has shown that a fair average of the amount of lumber required to construct forms in reinforced concrete buildings is as follows:

Boarding	1.15 FBM
Studding, etc.	2.65 FBM
Total	3.80 FBM

though some writers figure as low as 3 FBM per square foot.

It is seldom necessary to install all of the forms at once, and therefore, they can be used again. On the other hand, beam bottoms, posts, etc., must be left in place longer than the other portions of the formwork, so it is not possible to divide the quantity of material needed to build a form once by the number of times it is to be used, in order to determine the correct amount of material to be figured for each of the total number of square feet of forms to be made.

In fact, the actual speed of construction forms such an important factor in determining the amount of reposting that must be done, as well as the number of times the forms can be used, that it is almost impossible to determine the exact amount of lumber required.

Speed Highly Important.—However, the figures given in Table LIII are based upon past experience and are, therefore, safe to use under all ordinary circumstances.

Table LII gives the basis for figuring labor costs of concrete formwork by the contact area method.

The same remarks, as made under the heading of forms for plain concrete work, regarding the costs of moving

from stock-pile, re-building forms, and salvage, apply to the forms covered by Table LII.

Table LIII is based upon the ordinary rate of speed of one story each two weeks; increasing the speed to one story per week will increase the total quantity of lumber to be used by the percentages given in Table LIV.

TABLE LII.—LABOR COSTS ON FORMS

(Hours per 100 square feet)

	Assembling	Erecting	Stripping
Square columns:			
Laborers	2	2	3.5
Carpenters	6.5	2	.....
Spandrel beams:			
Laborers	2	2	3.5
Carpenters	5.5	2	.....
Beams and girders:			
Laborers	2	2	3.5
Carpenters	6	2	.....
Brackets and heads:			
Laborers	3.5	3	3.5
Carpenters	8.5	3	.....
Drop-panels:			
Laborers	3	2.5	3
Carpenters	6.5	2.5	.....
Slabs:			
Laborers	1.5	1.5	3
Carpenters	6.5	1.5	.....
Partitions, Walls:			
Laborers	3	3	3.5
Carpenters	5.5	2	.....
Stairs:			
Laborers	3	3	3.5
Carpenters	8.5	3	.....

TABLE LIII.—LUMBER QUANTITIES FOR FORMS

(Speed—two weeks per story. F. B. M. per square foot of contact area)

Height of Building (Stories)	Brackets and Columns	Girders and Beams	Slabs	Drop Panels	Wall Panels	Stairs	Average
1	3.8	3.4	2.7	4.2	2.2	4.5	3.8
2	3.8	3.4	2.7	4.2	2.2	4.5	3.8
3	2.6	2.8	2.3	2.9	1.9	3.9	3.3
4	2.0	2.5	2.1	1.5	1.5	3.0	2.5
5	1.6	2.1	1.7	1.3	1.3	2.6	2.1
6	1.3	1.7	1.5	1.1	1.1	2.2	1.8
7	1.2	1.5	1.3	1.0	1.0	1.8	1.6
8	1.1	1.3	1.2	1.9	0.9	1.7	1.5
9	1.0	1.2	1.1	1.9	0.9	1.6	1.4
10	0.9	1.1	1.0	1.9	0.9	1.5	1.4
11	0.8	1.0	0.9	1.9	0.9	1.4	1.4
12	0.8	0.9	0.9	0.9	0.9	1.3	1.4

The quantities given in the last column of Table LIII are for an average of a number of different buildings and

TABLE LIV.—LUMBER QUANTITIES FOR FORMS

(Percentages to be added to quantities in Table LIII for speed of one story per week)

Number of Stories	Per Cent	Number of Stories	Per Cent
2	30	7	72
3	60	8	60
4	80	9	65
5	70	10	50
6	65	11	50
		12	50

may vary somewhat from the average of any particular building.

Notes on Wood Column Forms.—From the table, opposite the height of the building in stories pick out the lumber per square foot of contact area and apply the figure to the total contact area.

When the top floor or several upper floors are of a smaller area than the rest, consider the building as two separate buildings; one building with each floor area equal to the area of the top floor and of a story height equal to the maximum story height of the building. The remaining floor area is applied to the lower building.

Example.—Six story building, 13–0 story height, no basement; 2nd, 3rd, 4th, 5th, 7 (roof) = 8,000 square feet each; 6th and roof = 4,000 square feet each. Floor area six story portion = 6 by 4,000 = 24,000 square feet. Fourth story portion (8,000–4,000) by 4 = 16,000 square feet.

Lumber—24,000 by 1.4 = 33,600 FBM
16,000 by 1.9 = 30,400 FBM
Total . . . = 64,000 FBM

Notes on Depressed Panel Forms.—The column for drop panels gives the lumber per square foot of drop panel, no deduction in area being made for column heads.

Example.—Three story building, flat construction with drop panels. Column 20–0 o. c., drop panels 7–0 by 7–0

20–0 by 20–0 = 400 square feet
7–0 by 7–0 = 49 square feet
351 square feet area of floor panel less drop panel.

Lumber
351 by 2.3 = 807 FBM
49 by 3.4 = 164 FBM
971 FBM total for a floor panel

$$\frac{971}{400} = 2.42 \text{ board feet per square foot of floor area}$$

Round Column Forms.—Steel round column forms are usually furnished upon a rental basis by the companies who manufacture them and it is their custom to make a lump-sum price for the complete installation and removal of the forms on an entire building.

Sometimes, however, the column forms are purchased outright by the builder, or rented without any service. In these cases, the cost of freight to and from the work, rent (or depreciation) and erection and removal must all go into the estimate.

The price (or rental) and freight must in each case be determined by inquiry. The best method is to send a complete schedule of the columns, by floors, to the column companies, giving diameter of columns, length from floor to underside of slab (or drop-panel) and dimensions of capitals.

The time required to install one column form, including the capital, remove it after pouring and clean it for re-use, will average 16 hours. The work can be done by handy men, under the direction of a carpenter, but Union rules may require it to be done by iron-workers.

Placing Reinforcing Steel.—In Tables XLI and XLII, Chapter V, information is given as to the method of figuring the cost of reinforcing steel for all comparatively plain work.

The times given in Table XLII for placing may be used for all slab work, except where the use of spacing bars or other devices is specified or for beams which are assembled in units with stirrups, or other shear members, or columns with hooped or spiral reinforcement.

The times given in Table XLII for bending should be used in all cases where it is desired to figure the bending separately.

When taking quantities from plans, it is essential that complete lists be made of all spacers, patent ties, supports, inserts, and all other specialties that are required and to figure their cost at prices to be obtained from the manufacturers or dealers, as well as the cost of installation.

The tables which follow will give the data for calculating e cost of placing reinforcing steel under various conditions a building.

Because of the great number of items that would result, ith ensuing complication of the estimate, it is not advisable adhere to the method of listing the number of bends in ch size of bars when figuring a large reinforced concrete ructure, but the tonnage of bars should be kept separate; rst, because the cost per ton of bending and placing steel creases as the weight in pounds per foot of bar decreases id, second, because the price per ton increases on all sizes low ¾ inch. Dealers also make an additional charge for ds cut to short lengths.

Some of the companies exploiting particular types of inforcing bars make a practise of quoting lump-sum figures r all of the steel, cut, bent and ready for assembly, accord- g to the plans and specifications but others only quote nit prices with extras for cutting and bending.

When sending lists for quotations, it is best to give the mber of pieces of each size and length required, together th diagrams showing any bending required.

Tables LV and LVI provide the data necessary for figur- g the cost of bending and placing steel in reinforced ncrete buildings of usual types.

This work is claimed by the metal-lathers or iron-workers, most parts of the country, but can readily be learned by ndy men working under competent direction.

Surface Finishes.—In a previous section we discussed w to compute the cost of any of the ordinary kinds of rface finish used on concrete work, as well as the cost granolithic and similar floors.

There are many different forms of special finishes that ay be applied to concrete surfaces but the most usual ethods of improving the wearing surfaces are by intro- cing metallic hardeners into the top coat or by coating e surface with liquid hardeners or waterproofing com- unds.

Most of the liquid compounds require from ¼ gallon to

TABLE LV.—BENDING REINFORCING STEEL

(Labor hours per ton)

Diameter of Bars	Beams, Columns, Etc.	Diagonally Reinforced Slabs	Other Slabs, Walls
Inch			
1 and over	3	2	2
¾	4.5	2.25	2.25
½ and ⅝	5	2.75	2.75
¼	5.5	3.25	3.25

TABLE LVI.—PLACING REINFORCING STEEL

(Labor hours per ton)

Diameter of Bars Inch	Walls, Beams, Columns, Etc.	Diagonally Reinforced Slabs	Other Slabs
1 and over	4.5	3.5	3.0
¾	7.5	6.0	5.5
½ and ⅝	12	8.5	8
¼	17	12.5	12

½ gallon of material and ½ hour of labor per 100 squa feet of surface for each application. The amount of ma terial, however, depends upon the consistency of the com pound as well as upon the porosity of the surface, so it well to get definite figures as to the covering capacity any compound under consideration.

Where metallic hardeners are used, they should alway be applied in strict accordance with the manufacturer

rections, for the kind of service required by the specifications.

These directions will give the quantities of hardener to used as well as the quantities of sand and cement.

The labor items are to be figured as previously explained.

CHAPTER VII

TIMBER FRAMING

SECTION I. GENERAL

When the writing of this text was considered, the pauci of the published data available regarding the cost of timb framing was astonishing. True, a great deal of informati has been published but it is all on the basis of the co per thousand feet B.M.

If all designers used the same details in mill constructio for instance, then a figure per thousand feet for that ty would have a real value. But rather costly experience h shown that the only safe way to determine the proba cost of a sizable job of mill construction is to determ the several operations that must be performed on ea stick and to estimate them separately.

This is not so formidable a task as it sounds. There generally a great number of sticks all exactly like another in every mill construction building. That is, on a floor most of the columns will be alike, most of the in rows of floor timbers will be alike and most of the ou rows of floor timbers will be alike.

Therefore, having found the cost for one stick, it is o necessary to multiply it by the number of similar sticks.

In a recent instance of a building, the cost of fram was figured on the basis of figures taken from previ experience and those figures also very closely approxim certain previously published cost figures. The estim was:

2 carpenters 8 hours each @ .85	$13.60
3 laborers 9 hours each @ .45	12.15
To frame 2,000 FBM	25.75
Estimated cost per 1,000	13.88

e actual cost was over $20 per M and the job super-endent claimed that the number of operations on each k made it impossible for him to show a lower cost.

Note that the term "framing" as used so far, includes actual framing operations as well as the operations of cting, and most published data follow the same plan. perience has shown that it is wiser to estimate the cost those two distinct operations separately. If one gets o the habit of figuring each distinct operation separately, will find that the temptation to "lump" and guess is atly lessened and that his estimates more nearly ap-oach actual costs.

Use your "costs per thousand" as a check on your de-led figures, if you like, but be sure to study the details. You have already learned how to compute the cost of ling materials when the weight is known, so if you

TABLE LVII.—WEIGHTS OF TIMBER

(Pounds per 1,000 F. B. M.)

	Rough	Dressed
llow pine	4,400	3,500
estnut	3,050	2,850
l oak	3,350	3,140
ite oak	3,575	3,250
uce	1,860	1,740
mlock	1,860	1,740

Note.—Very complete tables of the weights of many kinds of ber and lumber may be found in Stailey's "Lumber Inspection es" and in the "Yellow Pine Manual," the handbook of the thern Pine Manufacturers' Association.

know the weights of the various kinds of building lumbe you can readily figure the cost of hauling it from a car yard to the work. Table LVII gives that information.

Of course, the cost of handling varies greatly, dependi upon whether the lumber is taken from a box-car, a gondol or a flat-car, or whether it is taken from a pile. The ty of trucks or wagons used also have an effect upon the cos for instance, the "roller-dump" type of trucks and wago used in many places can be unloaded in less than a minut while other types require a very appreciable time of u loading.

Costs of handling timber from cars to trucks may figured from Table LVIII.

TABLE LVIII.—AVERAGE COSTS ON UNLOADING TIMBER AND LUMBER FROM CAR

(Labor hours per 1,000 F. B. M.)

	From Flat-car	From Gondola Car	From Box-car
Heavy mill timbers	1.0	1.5	1.0
House framing	0.4	0.5	0.5
Floor and roof plank	0.6	0.7	0.7
Boards	0.4	0.5	0.5
Flooring	0.7	0.8	0.8

Unloading from truck to pile will be two-thirds of t time required from flat-car to truck.

SECTION II. MILL CONSTRUCTION

Scaling the quantities for a mill construction buildi is a comparatively simple operation, but estimating t cost is not so simple, since, on a carpenter's wage rate

) cents per hour, the cost per thousand feet BM may sily vary from $7 to over $20.

This is all explained by the variation in details, one signer uses joint-bolts to provide a cross-tie for the ilding, another uses dog-irons, another depends entirely on the lag-bolts in the column-caps.

Some designers use cast-iron pintles to carry the load

TABLE LIX.—FRAMING MILL TIMBERS

(Time in hours of carpenter's time)

	Thickness of Timber				Any Size
	8″	10″	12″	16″	
oss-cutting, per inch of depth	0.04	0.05	0.06	0.07	.....
pping, per linear feet	0.14	0.16	0.20	0.28	.....
amfering, per linear feet	.....	.....	.....	.....	0.02
illing ¾-inch or smaller holes	.....	.....	0.02	.....	.....
illing 1-inch holes	.....	.....	0.03	.....	.....
illing 1½-inch holes	.....	.....	0.04	.....	.....
tting mortise for knee brace	.....	.....	.....	.....	0.30
tting V-notch for pintle	0.22	0.26	0.30	0.42	.....
tting square notch for post	0.25	0.30	0.35	0.50	.....
tting mortise for joint bolt	0.10	0.12	0.15	0.20	.....
tting notch for hook plate	0.12	0.15	0.18	0.20	.....

of an upper column to the capital of the column below while other designers permit the column itself to come dow into the capital.

All of these variations in design introduce operation which must be considered when estimating. Table LI gives the time in hours of carpenters' time for a numbe of different operations. Where the operation, such a cross-cutting, requires two men, proper allowance has bee made in the table so that the figures may be used withou change.

The figures in the table include an allowance to cove the time of shofting the boring-machine and other tool as well as moving the sticks into working position, turnin them as required, and also moving the stick out of th way when framing is completed.

Example.—An example of the method of figuring th cost of framing is as follows:

The floor beams in a certain silk mill are 10 by 18' 24-0 long. They are carried on duplex hangers at one en and on hook plates at the other. The table only take in sizes as high as 16 inches, so we will make proportionat allowances where necessary.

	hou
Plumb-cut at girder end	0.9
Fire-cut at wall end	0.9
Notch for hook plate	0.1
Chamfering 2 under corners, 22 feet each	0.8
	2.8

@ $1.125 = $3.1

Each stick contains 360 FBM, therefore the cost of fram ing 1,000 FBM would be $8.83 for the floor beams.

The girders are 10 by 18's, 16-0 long, carrying beam on each side every eight feet, the beams being sup ported by hangers which are let into the sides of th girders by two holes. The girders have a plumb-cut c each end. The cost is, therefore,

	hour
Plumb-cuts at both ends	1.80
Drilling 4 holes for beam hangers, holes 4 inches deep	0.16
Drilling 4 holes for dog-irons	0.04
Chamfering 2 under edges	0.56
	2.56

@ $1.125 = $2.88

Each stick contains 240 FBM, so the cost per thousand is evidently $12 for the girders.

The columns are 10 by 10's, 12-0 long, requiring only square cuts at top and bottom to fit into iron bases and caps. Their cost is:

	hour
2 square cuts	1.00
Chamfering 40 linear feet	.80
	1.80 @ $1.125 = $2.03

Each column contains 100 FBM, so the cost is evidently $20.30 per M for the columns.

This brings out one of the most dangerous features of the usual method of figuring on the basis of an assumed average hourly production or a cost per thousand feet. The columns, though each of them requires considerably less work on it than each of the floor beams requires, cost more than twice as much per thousand feet.

This is simply because the columns each contain less than half as many board feet as the beams do. This same condition exists throughout most jobs; for instance, a 6 by 6 column will contain only one-fourth as much material as a 12 by 12 column, yet the cost of framing it will probably be more than half as much as the cost of framing the 12 by 12. This will result in a cost per thousand that will be twice as high for the small sticks as for the large ones.

This same mill has a truss-roof on the top story. Each truss contains:

Chords	6 by 8	1/22–0	1/26–0	192
Rafters	6 by 8	2/24–0	.....	192
Struts	6 by 8	2/ 8–0	2/ 7–0	90
	4 by 6	2/ 6–0	.....	24
				498

The labor cost of assembling one truss will be:

	hour
End cuts on chords and rafters	1.92
End cuts on struts	2.16
Boring chord and rafter for 4 end bolts	0.22
Boring chord and rafter for 5 truss rods	0.20
Boring chord for 12 splice bolts	0.18
Notching chord and rafter for struts	3.00
Notching chord and rafter for rods, etc	3.50
Bolting up truss	2.00
	13.18

@ $1.125 = $14.83

Since the truss contains 498 FBM, the cost per thousand FBM is evidently $29.78.

Erecting Timber.—So far we have only figured the cost of framing. We must still estimate and add in the cost of the erection.

The cost of erection is a very variable item and will depend upon the equipment available, the height to which the timber must be raised above ground, the distance between timbers, and whether or not most of the work can be done by common laborers instead of carpenters.

While framing timber is very properly a carpenter's job there is no good reason why practically all of the work of erection cannot be done by good laborers, working under a competent carpenter foreman. However, in certain districts, the Unions may enforce regulations requiring that the work be done by carpenters.

For most mill jobs, the best sized gang will consist of eight men, using a hand-powered "wheel-derrick" and working as follows:

1 Foreman,
4 Laborers operating the derrick,
1 Laborer tending guy line,
1 Carpenter putting the timber in place,
1 Laborer helping the Carpenter.

Such a gang can handle timbers containing up to 400 FBM, each at the following speeds:

TABLE LX.—ERECTING TIMBER

(Time for full gang, as above)

Shifting derrick horizontally	2 feet per minute
Raising timber vertically	3 feet per minute
Setting timber in place	Average 5 minutes

These unit times contain a sufficient allowance to cover the ordinary small delays that occur in a day's work, but do not provide for any major contingencies.

Individual timbers containing over 400 feet BM are seldom encountered in ordinary mill construction (though we once handled a mill in Paterson, N. J., with timbers of 1,728 FBM, each, which is very exceptional) and the cost of erection per stick will advance practically one and one-half times its proportionate size beyond 400 FBM.

On the other hand, it takes practically as long to erect smaller timbers, until their size gets down below 200 FBM each, so the cost of erection per thousand feet becomes less as the size of the individual sticks increases until it reaches 400 feet per stick, after which it again advances.

In multi-story buildings there will usually be a steam-engine or electric-motor on the job for use in raising other materials and it can also be employed in getting the timber into the upper floors, from whence it can be erected by

the hand-powered derrick. In some cases the entire erection is handled by a power-derrick, but I believe the number of instances where this can be done economically is comparatively few.

Where the hoisting-engine is employed to lift the timbers onto the floors, it is usual to wrap the line around the winch or "nigger-head." Working this way will require two men on the ground to "load" the timber, two men on top to "unload," one man to tend the winch and the engineer to operate the derrick.

Such a gang should "load" and "unload" in a total of three minutes and should handle loads averaging 800 feet BM at a speed of 12 vertical feet per minute.

Applying these figures to the building under consideration, we get the following costs:

Cost of "Wheel-derrick" Gang per Hour

Foreman	$1.25
6 laborers @ $.45	2.70
Carpenters	1.12½
	$5.07½

Cost of "Power Hoist" Gang per Hour

Foreman (working)	$1.25
3 laborers @ $.45	1.35
Guyman	.50
Engineer	1.00
Engine	1.00
	$5.10

Erecting Second Story Timbers (from first floor)

Timbers are 8 feet center to center

Shifting derrick	4 minutes
Raising timber	4 minutes
Setting timber	5 minutes
	13 minutes = 0.22 hour

The third and fourth story timbers will take the same

length of time to erect, plus the time taken to bring them to the floors from which they are erected.

Thus third story timbers will require the time of the "power hoist" gang for each "load" as follows:

Load and unload	3 minutes
Hoist	1 minute
Total	4 minutes or 0.07 hour

The fourth story timbers will require 1 additional minute of hoisting time, making 5 minutes, or 0.084 hour.

The cost of erecting, exclusive of hoisting, is therefore:

For beams, 0.22 hour x \$5.07½ ÷ 360 = \$0.31 per 1,000
For columns, 0.22 x \$5.07½ ÷ 100 = \$1.12 per 1,000
For girders, 0.22 x \$5.07½ ÷ 240 = \$0.46 per 1,000

From their sizes it can be seen that two beams or three girders will just about make a "load" for the hoist. The columns could be hoisted eight at a time, so far as weight is concerned, but their shape makes it unlikely that more than four will be handled at once. Therefore the third-story hoisting cost will be:

For beams or girders, .07 hour x \$5.10 ÷ 720 = \$.60 per 1,000
For columns, .084 hour x \$5.10 ÷ 400 = \$1.08 per 1,000

In handling the trusses, the time for shifting the derrick will be the same as before, but even though each truss contains only 498 FBM, the time taken in hoisting and erecting it, because of its size and shape, will be twice as long as for a stick, and the time placing it three times as long. Since all the trusses go on one level, we can figure them as follows:

Hoisting gang time:

Load and unload	6 minutes
Hoisting 36 feet	6 minutes
	12 minutes or 0.20 hour

@ \$5.10 = \$1.02

Wheel derrick gang:

Shift derrick as before	4 minutes
Raising truss	12 minutes
Setting truss	15 minutes
	31 minutes or 0.51 hour
@ $5.07½	= 2.60
Total	$3.62

which equals $7.27 per 1,000

Note.—For convenience sake, it might have been better, as well as cheaper, to have hoisted the individual parts of the truss to the top floor and then assemble and erect them there. Where the element of time does not make it necessary to have the trusses ready to erect as soon as the walls can receive them, it will usually be found most economical to assemble them on the floor from which they are erected.

Summarizing the cost computed thus far, we get the following costs per 1,000 FBM:

	Framing	Hoisting	Erecting	Total
Beams:				
2nd floor	9.09	.....	0.31	9.40
3rd floor	9.09	0.50	0.31	9.90
4th floor	9.09	0.60	0.31	10.00
Girders:				
2nd floor	12.00	.....	0.46	12.24
3rd floor	12.00	0.50	0.46	12.96
4th floor	12.00	0.60	0.46	13.06
Columns:				
1st floor	20.30	.....	1.12	21.42
2nd floor	20.30	0.89	1.12	22.31
3rd floor	20.30	1.08	1.12	22.50
Trusses	29.78	2.04	5.23	37.05

Liability and compensation insurance, as well as overhead items and contingencies must, of course, be added

to these figures. It must also be remembered that we have only figured the cost after the timber was delivered to the site of the work and that the cost of delivery must be computed separately.

Since, counting the working foreman as a carpenter, the usual average throughout such a job as this would be 1½ laborers to a carpenter, a much more usual method of figuring is as follows:

1 carpenter 8 hours @ $1.12½	$ 9.00
1½ laborers 8 hours @ .45	5.40
Cost to handle 1,000 FBM	$14.40

This figure is to include framing, hoisting and erecting. To get the average for the building we have been studying we will figure as follows:

Second story:	
13,000 FBM beams, @ $9.40	$122.20
2,200 FBM girders @ $12.46	27.41
900 FBM columns @ $9.90	8.91
Third story:	
13,000 FBM beams @ $9.90	128.70
2,200 FBM girders @ $12.96	28.51
900 FBM columns @ $22.31	20.08
Fourth story:	
13,000 FBM beams @ $10.00	130.00
2,200 FBM girders @ $13.06	28.72
900 FBM columns @ $23.39	21.05
Trusses:	
9,000 FBM @ $37.05	333.45
57,300 FBM @ average of $15.00	$849.03

This would indicate that the error in the short method is less than 5 per cent when the conditions are all as outlined in our present example, but we can only tell what the

error would be in each other instance by working it out in detail.

SECTION III. BUILDERS' IRON-WORK

Computing the quantities of builders' iron-work is ordinarily a very simple operation; the exact method to be used depends largely upon the kinds of iron-work called for.

For instance, if any of the ready-made or patented types of joist-hangers, beam-boxes, column-caps, column-bases and similar members are called for, the simplest method is to make a list of the various items required and get a price on the list, either from a catalogue or price-list or by inquiry of persons dealing in such goods.

When the iron-work consists of members made up of ordinary sizes of rod, bar, or flat-iron, the weight can easily be computed by means of the tables in such handbooks as Cambria, Carnegie or Lackawanna, or if no handbooks are available, all of the various sizes can be figured to the equivalent of one-inch square bar, which weighs 3.40 pounds per linear feet, and the total weight thus readily calculated.

Manufacturers of such iron-work will usually be glad to give a unit-price per pound of lists sent them for price, or a unit-price per piece on each of the various items.

Where castings of any ordinary types, such as bases, caps, bearing-plates, pier-plates, etc., are used, unless a price per piece can readily be obtained, the contents of each piece in cubic inches should be calculated, and since a cubic foot of cast-iron weighs 450 pounds, the weight of the piece will be found by multiplying its contents by 450 and dividing by 1,728. Many estimators simply divide the cubic contents by four and consider the result near enough for all practical purposes.

A bricklayer with a laborer will set a base-plate, 16 inches square, and weighing 100 pounds in an average time of ½ hour and will take practically the same time for one of half that weight, while a beam bearing plate weighing 40 pounds, should not require over ten minutes.

With masons' time at $1.25 per hour and laborers' time at 60 cents per hour, the costs would be as follows:

Setting 100-pound base	.0083 per pound
Setting 50-pound base	.0165 per pound
Setting 40-pound base	.0065 per pound
Average for the three	.0101 per pound

It is hardly practicable to set up a table giving the unit times required for all of the different items of cast iron that might be used, but the information just given should enable you to figure the cost as closely as necessity warrants.

The time necessary for setting those items of iron-work that are placed by carpenters and which require boring and lag-bolting can be computed from Table LIX, by figuring the time necessary to do all the boring required and adding 1½ times that amount to cover the cost of bolting and assembling.

SECTION IV. HOUSE CONSTRUCTION

The work of framing and erecting the timber portions of houses and similar buildings is usually a very simple operation, practically the only items involving any complicated work are stairs, bay-windows, roofs and dormers.

Because house framing is so simple, the most usual method is to compare the building being estimated with some previous job, and then assume a comparative cost per thousand feet board-measure for the new work. This method is usually very satisfactory but sometimes apparently slight variations in the framing will make disproportionately large increases in the cost.

For this reason the same analytical method as outlined for mill-construction should be used to determine the unit-prices which will be used in a house-construction estimate for the framing, using the data in Table LXI, while for the erection the data given in Table LXII should be used.

It should be noted that the times given in Table LXII are for spruce, hemlock or other soft wood and they should

be increased as follows if hardwood framing timber is used:

For Hard Pine add 20 per cent to tabular time
For Chestnut add 25 per cent to tabular time
For Oak add 30 per cent to tabular time

TABLE LXI.—HOUSE FRAMING
(Time in carpenter hours per 100 pieces)

Joists	Fire-cutting (hours)	Square-cutting (hours)
2 by 8	16	14
2 by 10	18	16
2 by 12	24	22
3 by 10	25	22
3 by 12	30	27
3 by 14	35	32
Rafters	Main Rafters	Jack and Cripple Rafters
2 by 6	14	18
2 by 8	16	20
2 by 10	18	22
Wall Studs (Plates Same)	Cutting Both Ends and Notch for Ribbon	Halving for Splices, add
2 by 4	10	3
2 by 6	12	4

Partition Studs (Caps and Sills Same)	Cutting Both Ends
2 by 3	7
2 by 4	8
2 by 6	9
Main Sills (Halving Only)	
4 by 6	50
6 by 6	75
6 by 8	100
Hips and Valleys	(1½ Times Adjoining Rafters)
Bridging	2

The figures are all for hand-work and do not include the time required for laying out the cuts. If a template is made for each class of members, where there is much repetition, a great saving in time can be made, otherwise an increase of 50 per cent must be made in all of the above times to allow for laying out and measuring.

I have not attempted to give any figures for the use of power-saws as I do not believe they will show any economy on small jobs, and their economy on large jobs is entirely a matter of organizing the work so that the cost of handling the stock to and from the machine does not

eat up more than any possible saving which the machine might make.

In using Table LXI, note particularly that the cost of framing a stick is really independent of the length of the stick, so the cost of thousand feet BM will increase as the length of the pieces decreases.

An example of the working out of this point is as follows:

Assuming a carpenters' wage rate of $1.12½ per hour the cost of framing 2 by 6 rafters would be

$26.30 per 1,000 for 6-foot lengths....	167 pieces per 1,000
13.15 per 1,000 for 12-foot lengths...	84 pieces per 1,000
11.34 per 1,000 for 14-foot lengths...	72 pieces per 1,000
9.92 per 1,000 for 16-foot lengths...	63 pieces per 1,000

It can readily be seen that the use of this method eliminates the necessity of guessing how much should be added to the estimate for dormers, bay-windows, and similar features involving a great number of short sticks, since by counting the number of individual pieces required, and

TABLE LXII.—ERECTING HOUSE FRAMING

(Time in carpenter hours per 1,000 F. B. M.)

	Hours
Setting joists on masonry wall	9
Setting joists on main sill	11
Setting joists on girts or ribbons	12
Setting wall studs, including plates	7
Setting 2-story partition studs	7
Setting 1-story partition studs	11
Bridging joists	9
Bridging partitions	9
Setting ceiling beams	12
Setting main rafters	12
Setting jack and cripple rafters	17
Setting hips and valleys	17

figuring the cost on that basis, we have made the necessary allowance in the labor column and need only extend the materials at the proper price into the materials column.

In most cases it will be practicable to substitute from one-fourth to one-third of laborers' time for the carpenters' time given above, since a great deal of the work consists merely of handling and passing the lumber to the carpenters.

CHAPTER VIII

BOARDING, PLANKING, SHINGLING

SECTION I. PLANKING

While 1,000 feet board measure is undoubtedly the proper unit to use in calculating the quantities of materials required for all such items as floor and roof-planking, flooring, siding, sheathing, etc., the square, or 100 square feet, is the handiest unit to use when figuring the labor cost, and that unit has been used in all cases in this chapter.

In figuring the cost of the material necessary to lay a given area of planking, or boarding, due allowance must be made for the waste due to matching, cutting of ends, cutting out bad spots, etc.

If the planks for any piece of work can be ordered directly from the mill and if the spacing between supports is uniform, it is often possible to purchase plank so that practically the only waste will be that due to matching.

However, materials purchased from yard stocks are always subject to an over-run of 5 per cent, and due allowance must be made for this over-run when estimating. For instance, in a factory which required 100,000 FBM of floor and roof planking, all might be needed in 20-foot lengths.

If plank were ordered from a yard that did not have enough 20-foot pieces and added 21- or 22-foot pieces to make up the quantity, the purchaser would have to pay for that useless over-length up to a total of 5,000 FBM. Therefore, when estimating, be sure to determine whether stock will have to be purchased from yards and make allowance accordingly.

Side-waste, from matching, is a very uncertain quantity in planking, since it varies with the width of the plank. If it is known in advance that it is possible to get all planks of a given width, one could estimate accordingly, but

The increase in price when all plank of one width are specified will usually over-balance any possible saving.

Since matching usually takes ¾-inch from the width of a plank, it is evident that the percentage of side waste must be as follows:

4-inch wide planks	18¾ per cent.
6-inch wide planks	12½ per cent.
8-inch wide planks	9⅜ per cent.

An ordinary lot of random width floor or roof plank will not average over 6 inches wide, so it is well to allow at least 12½ per cent for the side waste.

If the distances between supports are not uniform, or, if those distances are not such that readily obtainable lengths of plank can be used, then additional allowance must be made for end-waste on that account.

In most markets, planks are usually available in lengths varying by multiples of 2 feet, from 12 feet upward. This means that, no matter what the actual length of plank required, the user must buy and pay for planks of the next larger length in even feet.

Thus, for an actual length of, say 18 feet 4 inches, he would have to buy 20-foot planks and waste the difference, or 9.3 per cent.

Adding this end-waste of 9.3 per cent to a side waste of 12.5 per cent we would have a total waste of 21.8 per cent or practically 22 per cent, which must be added to the estimate.

When splines are used, which is seldom the case with plank of a nominal thickness less than four inches, their cost is determined by allowing one foot of spline for each linear foot of plank.

Thus, if the plank average 4 inches wide, the total linear feet of splines will be three times the total area of planking; if 6 inches wide, twice the area; if 8 inches wide, one and a half times the area, and so on.

Various tables have been published for computing the quantities of nails or spikes required for floor and roof-

planking, but most of these tables give quantities very much smaller than will actually be used.

Ordinarily, spikes used in planking should not be much shorter than ½ inch less than twice the nominal thickness of the plank, thus:

For 4-inch plank use 7-inch spikes, figure 9 to the pound
For 3-inch plank use 60d spikes (6 inches long) figure 12 to the pound, or
For 3-inch plank use 50d spikes (5½ inches long) figure 15 to the pound
For 2-inch plank use 16d spikes (3½ inches long) figure 51 to the pound.

The number required will be determined by allowing 2 nails, or spikes, for each plank on each bearing. Thus planks 6 inches wide, 20 feet long, on 10-foot bearings, would require 6 nails per plank or 0.6 nails per square foot or 60 nails per square.

On this basis the quantities would be as follows:

TABLE LXIII.—NAILS REQUIRED

		Per Square (pounds)	Per 1,000 FBM (pounds)
4-inch plank.....	6-foot supports	11.2	28
	8-foot supports	8.4	21
	10-foot supports	6.7	17
	12-foot supports	5.6	14
3-inch plank.....	6-foot supports	8.4	28
	8-foot supports	6.2	21
	10-foot supports	5.0	17
2-inch plank.....	4-foot supports	2.8	14
	6-foot supports	2.0	10
	8-foot supports	1.4	7
	10-foot supports	1.1	6

These are the actual quantities required but, because of the many wastes that occur on every job, it is always well to allow an increase of 50 per cent of the computed quantities when estimating.

Whenever the conditions are such that the planks can be ordered of a very few lengths, that will work without further cutting, it is well to buy them "butted to exact length."

Dealers usually make an extra charge for butting but their charge is usually small as compared with the cost of butting on the job, even though power-saws are available.

Having figured the cost of landing the planks at the level at which they are to be laid, as previously explained, we now have only to figure the cost of placing, including the setting in of splines, when specified, and the cost of spiking.

The cost of placing plank, because of the inconvenience in working and moving around, naturally increases as the plank-span increases. On the other hand, since the number of nails per bearing is usually the same, the cost of nailing or spiking increases as the distance between bearings decreases.

For all practical purposes, therefore, the same cost may be figured for all reasonable variations in plank-span length.

TABLE LXIV.—LABOR HOURS PER 100 SQUARE FEET

Nominal Thickness (inches)	Tongue and Grooved	Splined	Laminated
2	3	.....	.....
3	3.5	4.5	.....
4	.....	5	7
5	.....	5.5	8
6	.....	6	9

The column for splined plank includes the time necessary for placing the splines.

The time in Table LXIV is given entirely in labor hours because local conditions will determine what portion of the work can advantageously be done by laborers and what portion must be done by carpenters. Beyond the butting of the plank, however, there is really very little work connected with the laying of plank that requires the skill of the carpenter.

SECTION II. FLOORING, BOARDING, SHEATHING

In the previous discussion of the cost of timber-framing, you have become familiar with the cost of transporting lumber to the site of the work and of placing it on the level at which it is to be used, and no repetition is necessary here.

The same general principles apply to the application of flooring, boarding, sheathing, ceiling, etc., as apply to the laying of floor and roof-planking, but in these present items a greater number of factors affect the amount of waste involved and the amount and quality of the labor required.

If we always knew in advance that our lumber would be as good as we expect it to be, and our architects no more exacting than we read their specifications to be, it is probable that we could figure upon a less proportion of waste material and a greater production per man-hour.

Under present market conditions, and with present grading rules, we are always likely to have to do a great deal of cutting out and rejecting, which means waste of material and added cost for labor.

In preparing the following tables, all of these conditions have been given consideration and allowance made accordingly. In figuring, it is assumed that the estimator will always consider small openings as part of the area to be covered, making no allowance for the saving and, in the cases of irregular or badly broken-up areas, he will make a judicious addition to the figured allowances for labor and for waste material.

TABLE LXV.—FLOORING, SHEATHING, ETC.

(Carpenter hours per 100 square feet)

	Time	Add Percentage of Waste Required	Nails (Pounds)
3¼ face NC or fir flooring	2.8	15	4.5 (on underfloor)
2¼ face NC or fir flooring	3.0	25	5.5 (on underfloor)
3¼ face NC or fir flooring	3.3	20	4.5 (on joists)
2¼ face NC or fir flooring	2.5	30	5.5 (on joists)
2¼ face oak	3.0	20	5.5 (on underfloor)
2¼ face beech, birch or maple	2.8	20	5.5 (on underfloor)
1x6 underfloor on joists	1.7	15	2.0
1x8 underfloor on joists	1.5	15	1.7
1x6 underfloor on joists	2.2	25	2.0 diagonal
1x8 underfloor on joists	2.0	25	1.7 diagonal
x6 roofers on sidewall studs	2.4	15	2.0
x8 roofers on sidewall studs	2.2	15	1.7
x6 roofers on flat roof	2.2	15	2.0
x8 roofers on flat roof	2.4	15	1.7
x6 roofers on pitched roof	2.6	25	*2.2
x8 roofers on pitched roof	2.8	25	*1.9
Narrow ceiling on sidewalls	3.5	25	2.0
Narrow ceiling on ceiling	4.0	25	2.0
Narrow clapboards on walls	4.0	25	2.0
Wide clapboards on walls	2.5	25	1.6

*Add one hour to total figures for each 10 linear feet of hips, ley and ridges in the roof and 1½ feet BM waste lumber for each ear foot of hip, valley and ridge.

SECTION III. SHINGLING

While the square seems to be the most convenient unit for use in figuring the items just discussed, shingles can better be figured by the thousand.

This is true because, even though the number of squares must be taken off the plan in order to compute the quantity of shingles required, it takes just as much labor to lay a thousand shingles with a 4-inch exposure to the weather as with a 5-inch exposure, the area covered will be materially less.

Shingles, as delivered, vary in width but are counted on the basis of 4 inches wide, so the actual number of pieces in a bundle is immaterial but the charge is for a quarter-thousand.

Shingles are usually made 16 or 18 inches long but, since the exposure to the weather is what governs the quantity used, the length makes no difference in the number required but will make a difference in the cost, because the 18-inch shingles cost more per thousand.

Also, because of the greater lap afforded they make a warmer house.

Shingles on roofs are usually laid 4, 4½ or 5 inches to the weather, on sidewalls they may have as much as 10-inch exposure and sometimes are laid with the courses alternating, first a course of narrow exposure, then one of wide exposure.

Since the shingles average 4 inches in width, when laid 4½ inches to the weather, each shingle covers 18 square inches and 8 shingles cover one square foot. Upon this basis we may calculate our table as below.

The usual method of figuring the labor, as given in most handbooks, is to take a certain figure for "plain roofs" and another one for "fancy roofs," but that hardly seems definite enough, so the following method is recommended.

To these figures it is necessary to add 10 minutes time for each linear foot of door- or window-casing or similar trim against which the shingles must be fitted, and also 2 minutes time for each linear foot of ridge hip or valley

TABLE LXVI.—SHINGLES REQUIRED PER 100 SQUARE FEET

Exposure	Number Required	Nails Required
(inches)		(pounds)
4	900	3.9
4½	800	3.5
5	720	3.3
6	600	2.7
7	515	2.3
8	450	2.0
9	400	1.8
10	360	1.6

TABLE LXVII.—LABOR PER 1,000 SHINGLES

On straight roofs	2 hours carpenter time
On curved surfaces	2.5 hours carpenter time
On side walls	2.7 hours carpenter time

With these additions, the tabular figures will be large enough to cover erecting and taking down the usual amount of scaffolding.

With the great variety of asphalt, and other forms of proprietary shingles that are now on the market, it is hardly practicable to prepare a table that would cover them all, but the following figures will prove helpful.

TABLE LXVIII.—LABOR PER 100 SQUARE FEET

Asphalt strip shingles	2 hours carpenter time
Asphalt twin shingles,	2.25 hours carpenter time
Asphalt single shingles	2.75 hours carpenter time

SECTION IV. FURRING AND GROUNDS

No attempt will be made here to discuss the cost of affixing the many kinds of patented furrings and "spot" grounds. The manufacturers of most of such articles have collected data on their cost of installation and are glad to furnish information at any time. When using such information, however, it is necessary to be sure that it is in such form that it can be applied to the problem in hand.

Some strip furring is figured by the square, which is all right if the proper allowances are made for waste, etc., but, since furring is often sold on the basis of the number of linear feet, I recommend that method of figuring.

Knowing the spacing, it is a simple matter to calculate the number of linear feet required, and then an allowance of at least 10 per cent should be added to cover end-waste on strips, short pieces, cross strips, etc.

The labor can readily be figured by means of Table LXIX.

TABLE LXIX.—FURRING

(Carpenters' time per 1,000 linear feet)

	On Joists	On T. C. Tile	On Gypsum Tile	On Brick
1 by 2..	7	11	10	13
2 by 2..	8	13	12	15
2 by 3..	8.5	14	13	17

The figures for furring on brick are based upon the assumption that plugs have already been placed in the wall. If wood plugs must be inserted, add 6 hours to the figures given in the table.

The item of grounds affords more opportunities of guesswork than almost any other item in the carpenter's estimate. This is true because few people take the time to compute

he quantities required or make any actual effort to find what it really costs to affix grounds.

Care should be taken to include grounds for every kind of wood trim that is to be attached in plastered rooms and to study the detailed drawings carefully to find out just how much grounding is necessary.

Ordinarily, the following figures should be used:

For base, 2 linear feet grounds per linear foot.

chair rail, 2 linear feet grounds per linear foot.

picture-mould, 1 linear foot grounds per linear foot.

casings, 1 linear foot grounds per linear foot.

The labor may be calculated from Table LXX.

TABLE LXX.—GROUNDS

(Carpenters' time per 100 linear feet)

	Hours
On brick	5
On terra cotta	4.5
On gypsum	4.5
On wood	4

If plugging of brick walls must be done, then the same allowances must be made as for furring.

CHAPTER IX

FINISHED CARPENTER WORK

SECTION I. GENERAL INSTRUCTIONS

It is hardly within the province of this Chapter to attempt to give a detailed explanation of the method of figuring the cost of mill-work materials, since that is the manufacturers' job rather than the construction estimator's, but it will be in order to suggest the methods to be used in taking off quantities and securing prices.

If the materials required are all of stock sizes and patterns, it is a simple matter to make a complete list of the items required, price them from a catalogue and discount sheet, or send the list to dealers and have them quote on it.

If the material is only partly of stock patterns, part of it can be priced from the catalogue as above, or all of it sent out for prices, but if the patterns are at all unusual, it is always best to have the mill-estimator take his own quantities directly from the plans.

When sending out lists for prices, it is well to transcribe all those parts of the specifications that describe the kind, size or quality of members required. Also note carefully every given dimension of all of the different members required.

For instance; window-frames should have dimensions given for outside-casing, pulley-stile, head-casing (also whether square- or segment-head), parting, beads, sills, etc. also complete description of pulleys if any are to be installed.

Sash should have dimensions given for thickness and width of stiles and rails, kind of glass and number of lights.

Doors should be completely described by size, thickness, number of panels and material and, if possible, accompanied by sketch.

Window-trim should have dimensions and descriptions of inside-casings, head-casings, stops, stools, aprons, also false-jambs, back-bands, scotia, etc., if required.

There are many methods of procedure used in taking off and listing the quantities but the one that is simplest and most readily checked is as follows:

After having made all of the notes referred to above, make headings, thus:

Basement:
- Door frames,
- Window frames,
- Doors,
- Sash,
- Stair-treads,
- (other items, if any)

after each heading, put down the number and size of each required, then proceed with the

First Floor:
- Door frames,
- Window frames,
- Doors, exterior,
- Doors, interior,
- Sash,
- Door Jambs,
- Door Trim,
- Window Trim,
- Base,
- Chair-rail,
- Picture mould,
- Beam-casings,
- Beam Soffits,
- Stair-rail,
- Balusters,
- Newels,
- Treads,
- Risers,
- Etc., Etc.

Door- and window-trim is listed by writing down the number of "sides" required. A "side" consists of a complete set of material necessary to trim one side of an opening; thus, an inside door requires two sides of trim, while an outside door or a window requires only one side. Door jambs are listed by the "set."

If the description previously mentioned is given, any mill-estimator will be able to calculate the cost of a side of door-trim or a side of window-trim and will quote accordingly.

Because of the allowances that must be made for waste, few mills will make any difference in the price of a side of trim for a 2 feet-6 inches by 6 feet-6 inches door and one for a 2 feet-0 by 7 feet-0 door. In fact, unless you ordered the casings cut to length and made up in "cabinet-trim" you would probably receive them in 7-foot or 14-foot lengths, where mitering is not required and 16-foot lengths if the trim is to be mitered at the head.

Where the builder is willing to take the extra trouble incurred in handling the materials at the work, he can often buy his mill-work more cheaply by simply ordering a sufficient number of linear feet of casings, stops, plinth, back-bands, window-stools, etc.

Stairs, pantries, cupboards and mantels should be fully described and sketches sent whenever possible.

For approximate estimating, the simplest method is to price frames, doors and sash from catalogues, then if the items are such that they cannot readily be priced in that way, calculate each member into "moulding-inches" and price it at the prevailing price per 100 linear feet per "moulding inch."

A moulding inch is the equivalent of a piece 1 inch square and 1 foot long, and is figured upon the basis of the full size of stock from which the moulding must be made.

Get the prices for different woods from a reliable mill and calculate the quantities by multiplying the dimensions of each member thus:

A ¾ by 4¾ casing must be cut from a 1 by 5 board, therefore, it equals 5 moulding inches.

Follow this method through for each member.

When listing mill-work be careful to note whether any priming-coat is to be applied or if any back-painting is to be done at the shop and, when ordering, be sure that no priming-coat is put on any surfaces which are to be stained instead of painted.

SECTION II. INTERIOR WORK

You are now ready to attack the labor estimate, and can use the following figures in computing the cost.

TABLE LXXI.—INTERIOR WOOD-WORK

(Hours carpenter time per 100 linear feet)

	Soft Wood	Hard Pine	Oak	Mahogany or Gum
Base	4.5	5.7	6.2	6.8
Base-mould	1.7	2.1	2.4	2.6
Floor-mould	1.5	1.9	2.1	2.3
Chair-rail	4.0	5.0	5.5	6.0
Wainscot-cap	3.8	4.8	5.3	5.8
Picture mould	3.5	4.4	4.8	5.4
Beam casings	4.5	5.7	6.2	6.8
Beam soffits	4.5	5.7	6.2	6.8
*Beam cornice	5.0	6.3	6.9	7.5
*Panel stiles	7.0	8.8	9.7	10.5
*Panel mouldings	7.0	8.8	9.7	10.5
Plate rail	6.5	8.1	9.0	9.8
Plate rail-apron	6.5	8.1	9.0	9.8

*Add 5 minutes for each miter required.

NOTE.—To obtain these results, one laborer will be required for each four carpenters; therefore, an allowance of 1 hour of laborers' time should be added for each four hours of carpenters' time.

TABLE LXXII.—DOORS AND WINDOWS AND TRIM

(Hours per single opening 3 feet–0 by 7 feet–0 or less)

	Soft Woods	Hard Pine	Oak	Mahogany or Gum
Fit sash	2.0	2.5	3.0	.....
Attach weights and cord	1.0	1.0	1.0	.....
Attach weights and chain	1.25	1.25	1.25	.....
Attach sash fasts	0.2	0.2	0.2	.....
Attach flush lifts	0.3	0.4	0.4	.....
Attach bar lifts	0.2	0.2	0.2	.....
Attach pole socket	0.2	0.2	0.2	.....
Install stops with adjusters	0.5	0.5	0.5	0.7
Install stops with screws	0.4	0.4	0.4	0.6
Install false jambs	1.5	2.0	2.2	3.0
Install casing, stool and apron	2.0	2.5	2.5	3.0
Fit door	2.0	1.5	1.8	2.0
Attach butts (per pair)	0.6	0.8	0.9	1.2
Attach spring butts	1.5	1.7	1.8	2.5
Attach floor hinge	2.0	2.2	2.5	3.0
Attach flush bolts	1.0	1.2	1.5	2.0
Attach cremorne bolts	1.5	1.7	1.8	2.5
Set jambs	0.5	0.5	0.8	0.8
Plant on stops	0.8	0.8	0.9	1.3
Set casings	2.5	2.9	3.5	3.9
Set back bands	1.0	1.2	1.5	2.0
Set plinths	1.0	1.2	1.5	2.0
Add for mitered heads	0.5	0.5	0.6	1.0
Set cap mould	0.5	0.5	0.5	1.0
Attach mortise lock	1.0	1.2	1.5	2.5
Set transom	1.5	1.7	1.8	2.5
Install transom catch	0.6	0.8	0.9	1.2
Install transom operator	1.0	1.2	1.5	2.0

NOTE.—The same addition must be made for laborers' time as in Table LXXI.

The amount of time indicated in these tables, for the several kinds of work, is sufficient to cover all direct labor from the time the materials are delivered inside of the building.

It requires practically as long to perform the work on a smaller opening as it does on one up to 3 feet-0 by 7 feet-0, but, when the openings are larger, the weight of the materials to be handled becomes so great and the

TABLE LXXIII.—STAIR-WORK

(Hours of carpenters' time)

NOTE.—Figure all rough carriages for stairs, also all rough stairs, such as are sometimes used for cellar stairs, according to the method delineated for timber-framing, but be sure to make allowance for each carriage, or stringer, each tread and each riser and all necessary cuts.

	Soft Woods	Hard Pine	Oak	Mahogany or Gum
Housing out stringers (per tread and riser)	0.5	0.6	0.7	0.9
Fitting plain rabbeted treads	0.3	0.4	0.5	0.8
Fitting plain plowed risers	0.3	0.4	0.5	0.8
Cutting open stringers (per tread and riser)	0.4	0.5	0.6	0.8
Miter return on end of open stairs treads	0.3	0.4	0.5	0.7
Placing scotia, per 100 feet	2.5	3.0	3.5	4.5
Placing skirt mould, per 100 feet	3.0	3 5	4.0	5.0
Placing skirt board, per 100 feet	5.5	6.7	7.2	7.8
Placing baluster rail, each 10 feet	3.0	3.0	3.5	4.0
Placing wall rail, each 10 feet	1.0	1.0	1.5	2.0
Placing balusters each	0.1	0.1	0.1	0.2
Setting newels each	1.0	1.0	1.5	2.0

amount of work to be done is so much that the time allowances must be increased proportionately.

One hour of laborers' time should be added for each 8 hours of carpenters' time on stair-work. Because of the nature of the work, the mechanics do not handle as great a volume of material as when on other forms of interior wood-work, so a smaller number of laborers may be employed than on trim.

TABLE LXXIV.—MISCELLANEOUS INTERIOR WOOD-WORK

	Soft Woods	Hard Pine	Oak	Mahogany or Gum
Placing 4-feet high "made-up" panelled wainscot, per 100 linear feet	15.0	15.0	17.0	21.0
Ditto 6 feet high	17.0	17.0	19.0	28.0
Ditto 8 feet high	19.0	19.0	21.0	3.00
Fitting and hanging cupboard doors	0.6	0.7	0.7	1.0
Setting drawer cases	1.5	1.5	1.5	2.0

It is obviously impracticable to list here all of the various fittings and fixtures that might be introduced under the heading of Interior Wood-work, but there are very few instances where the work to be done cannot be analyzed into its component operations and, having done that, the cost can be calculated from the information given in Tables LXXI to LXXIV.

Care must always be taken to see that sufficient grounds or blocking have been provided to properly secure all interior wood-work and all of those items should be included in the estimate under their proper headings, as previously explained.

Where the finish is specified to be hand-smoothed o

bench-sanded," the allowances included in Table LXXV must be included in the estimate.

TABLE LXXV.—SANDING INTERIOR FINISH

(Hours carpenters' time per 100 square feet)

	Plain	Moulded
Hard woods	1.25	1.50
Soft woods	1.00	1.25

NOTE.—Members under 6-inch wide should be counted as 6-inch and all wider than 6 inches should be counted as a foot wide, or when the actual width is greater than a foot, then their actual width. This is because it takes about as much time to handle a narrow piece as it does to handle a wide one.

Be sure to include as many sides or edges of the member as are to be exposed.

Nails.—It would be futile to attempt to compile an accurate schedule to indicate the number of nails required for the various operations included in interior wood-work, but an allowance of 2 pounds of nails for each 100 linear feet of casing, stool, apron, mouldings, etc., will cover all that are actually used, as well as those that are usually wasted.

SECTION III. EXTERIOR WORK

TABLE LXXVI.—EXTERIOR WOOD-WORK

(Hours of carpenters' time per 100 linear feet)

Box cornices, each member	3.0
Open cornices, for each moulding cut between rafters	5.0
Corner boards and water table	3.5
Facing false rafters (each)	0.0
Facing porch posts	2.0

NOTE.—The same allowances should be made for the extra cost of joiners and for laborers' time as given in Table 71.

TABLE LXXVII.—DOOR AND WINDOW FRAMES

(Hours of carpenters' time per unit)

	Masonry Wall	Stud Wall
Setting single door frames	1.75	1.50
Setting double door frames	2.75	2.50
Setting single window frames	1.25	1.00
Setting double window frames	1.75	1.50
Setting triple window frames	2.75	2.50

These costs include necessary bracing, plumbing, attaching anchors, etc.

CHAPTER X

STRUCTURAL STEEL AND IRON WORK, STEEL SASH

SECTION I. STRUCTURAL STEEL

If this book were intended for the use of workers in tructural steel and iron works, we should take up in etail the subject of the costs of the various items of hop-work that enter into the preparation of steel and on-work for buildings.

This book, however, is intended primarily for the use f general contract estimators, and will therefore only over those portions of the work handled by a builder.

Of course, on jobs involving a large tonnage of steel, he builder will prefer to sub-let the erection, either to the ompany furnishing the steel or to someone who specializes steel-erection and who will have the necessary equip-ent of engines, derricks, riveting machinery, etc.

In estimating the cost of erection, the same care should e taken as when figuring to furnish the material, except hat no count need be taken of shop-rivets, nor need any ention be made of such strictly shop-items as coping eams, etc.

Of course, in making a list of steel for pricing or purchase, will be necessary to describe all punching, coping, shop-veting, etc., to be done on each piece.

When listing for estimating, or for purchasing, keep the llowing facts in mind:

Wall-bearing beams always require steel or cast-iron earing-plates under each end, and nearly always have anchor of some sort as well.

Beams framing into other beams, or into girders, require

connection angles and bolts, or rivets, at all connections.

Girders, lintels, grillages, and other members made up of more than one unit, require bolts and separators to hold them in proper assembly.

Trusses are often shipped in sections and, therefore, require bolting up in the field.

Even though seldom indicated on small scale plans, trusses usually require gusset plates at the connections between the several members.

Many of the items mentioned here are frequently omitted from the drawings but are covered by some general clause in the specifications that requires the contractor to furnish everything necessary to make a complete job. This is manifestly unfair, but since contractors continue to bid for and accept work on that basis, it is a condition with which we must contend.

When no sizes are given for these various sundries, the estimator must assume that they are the standard sizes for the conditions. Every estimator who has frequent occasion to figure on steel work should, therefore, provide himself with a copy of some such handbook as that issued by Cambria Steel Company, which gives complete data on all standard construction.

When listing steel for purchase, the items should be set down in some such manner as follows:

STEEL FOR JONES BLOCK, BONDSVILLE, MASS.

First story:

Three 12-inch–31.8-pound I-beams, 19 feet–8 inches long (Wall bearing.)
Five 10-inch–25.0-pound I-beams, 19 feet–8 inches long (Wall bearing.)
Six standard bearing plates for 12-inch–31.8-pound I-beams
Ten standard bearing plates for 10 inch–25-pound I-beams
Ten lintels, each consisting of
Three 4 by 4 by 3/8 angles 5 feet–8 inches long loose.
Five lintels, each consisting of
Two 10-inch–15-pound channels 8 feet–8 inches long.

Two standard separators for same.
Two 10 by 12 by 1/2 bearing plates.

econd story:

Six 10-inch–25-pound I-beams, 20 feet–4 inches long. (Wall bearing.)
Four 9-inch–21-pound I-beams, 8 feet–0 inches long. (Wall bearing. One end standard connection on other.)
Two 10-inch–25-pound I-beams, 20 feet–4 inches long. (Wall bearing, punched for connection of 9-inch–21-pound I-beam, 8 feet from each end.)
Ten lintels, each consisting of
Three 4 by 4 by 3/8 angles, 5 feet–8 inches long, loose.
Three lintels, each consisting of
Two 8-inch–11.25-pound channels, 8 feet–8 inches long.
Two separators for same.
Two 8 by 8 by 3/8 bearing plates.

Such a list would give a practical steel man a fair icture of what was required, but if used in taking off steel uantities from a large set of plans, for the purpose of guring erection only, quite a bit of time would be con-umed just in writing down items.

For figuring erection, the following method is as com-lete as needed, and gives the same results.

irst floor beams,
(3) by 19 feet–8 inches by 31.8 pounds.
(5) by 19 feet–8 inches by 25.0 pounds.
Six bearing plates at 31.0-pounds.
Ten bearing plates at 17.0-pounds.

intels,
(30) by 5 feet 8 inches by 9.8-pounds.
(10) by 8 feet 8 inches by 15.0-pounds.
Ten separators, including bolts at 8.1-pounds.
Ten bearing plates at 17-pounds.

econd story beams,
(8) by 20 feet 4 inches by 25.0-pounds.
(4) by 8 feet by 21.0-pounds.

Twenty bearing plates at 17-pounds.
Four connections at 13-pounds.

Lintels,

(30) by 5 feet 8 inches by 9.8-pounds.
(6) by 8 feet 8 inches by 11.25-pounds.
Six separators at 5.9-pounds.
Six bearing plates at 6.8-pounds.

Field bolts,

Second floor, 4 connections at 4 = 16 bolts.

If preferred, the parentheses and multiplication signs may be omitted and quantities tabulated thus:

Name	Number	Length (feet and inches)	Weight per Foot (pounds)	Total
Beams.....	8	20 4	25	4,066
Beams.....	4	8 0	21	672
Bearing plates...	20		17 (each)	340
Connections.....	4		13 (each)	52

And this affords an opportunity to note that of a total weight of only 5,130 pounds, 392 pounds, or practically 8 per cent of the total, is in items that are often omitted from the plans but which must be purchased and installed by the contractor. Some estimators make a practice of only listing the members shown and then allowing 10 or 15 per cent for sundries.

After calculating the weight of material to be handled, it is necessary to figure the cost of getting it to the work, unless it is purchased for delivery at the site, and of erecting it in place.

Sizes of individual members, as well as facilities for

handling, have such a marked effect upon the cost of handling that it is very difficult to set down general rules for estimating that would cover every case, but the data presented here are on the side of safety and may be used with confidence.

There is no reason why practically all of the steel work in wall-bearing buildings cannot be erected by ordinary laborers, when under competent supervision, except that union rules do not permit it. However, in many districts union rules are not effectually enforced and laborers do the erection.

It is important to know, when figuring on work of any size, whether it can be handled by laborers or not as the difference in wage rates will make an appreciable difference in the cost per ton.

Of course, setting up the derrick and similar work should always be done by a competent man.

When no crane is available at the point of unloading from cars, it will be necessary to set up a derrick to handle the steel, unless the amount to be handled is so small that it is thought advisable to handle it by some less convenient means, and proper allowance should be made for setting up and taking down this unloading derrick.

The actual hauling cost can be estimated from the information given in earlier papers.

Allowance must also be made for the cost of setting up and taking down the derrick used at the building, as well as for moving it from time to time.

For such operations as erecting trusses over one-story buildings, heavy individual girders and similar members, a gin-pole is often preferable to a derrick.

When pneumatic hammers are used to drive rivets, an allowance of at least 40 hours must be made for installing and removing the compressor and reservoir, and the hoisting-engineer will also receive additional pay at the rate of one-half his regular pay for taking care of the compressor.

TABLE LXXVIII.—MISCELLANEOUS OPERATION

(Time in man-hours. Where local conditions will permit, an average of 1 foreman, 1 tradesman and 3 laborers make a good gang; elsewhere figure 1 foreman to 4 tradesmen)

	Erect	Move 20 feet Horizontally	Raise 2-stories Vertically	Take Down
Gin-pole	40	15	.....	10
Guy-derrick	60	20	60	20
Breast-derrick	10	3	5	3

TABLE LXXIX.—UNLOADING, ERECTING STRUCTURAL STEEL

(Man-hours per ton)

	Unloading	Erecting
Wall-bearing beams	2	8
Skeleton construction	2	6.5
Roof trusses	2.5	14.0
Roof purlins	2.5	16.0

TABLE LXXX.—RIVETING AND BOLTING

(Units per man-hour)

	Bolts	Hand-driven Rivets	Air-driven Rivets
Wall-bearing construction	20	.....	.....
Skeleton construction	15	8	15
Trusses and purlins	15	6	12

Using the figures given in these tables, an average skeleton framed building, having 200 tons of structural steel, on eight tiers, would figure out as follows:

	Hours		
The gang is assumed to consist of—			
1 foreman @ $1.50 per hour			$1.50
1 engineer (1½ rate) @ $1.33 per hour			2.00
4 iron workers @ $1.00 per hour			4.00
Average price per hour			1.25
From Table LXXVIII—			
Set up derrick	60		
Lift three times	180		
Take down	20		
Set up and take down derrick at freight yard	120		
From Table LXXIX:			
Unload 200 tons @ 2 hours	400		
Erect 200 tons @ 65 hours	1,300		
From Table LXXX:			
10,000 air driven rivets @ 15 per hour	667		
	2,747	@ $1.25	$3,433.75
Compensation insurance, 8 per cent			274.70
Carting 2 miles on hard road = 67 trips @ 1½ hours = 112 hours @ $1			112.00
Insurance @ 3 per cent			3.36
Allowing for rainy days and other delays, approximately 45 days would be consumed by the work and, allowing $10 per day for fuel, lubricants and fixed charges on equipment			450.00
Total for 200 tons			$4,273.81
Average cost per ton			$21.37

The number of rivets was assumed in this case, in actual practise it should always be determined carefully from the plans.

Since it is quite a common practise to include the field

coats of paint on structural steel in the erection contract, it is necessary to figure on that work also.

TABLE LXXI.—AREA OF STRUCTURAL STEEL

(Approximate number of square feet of surface per ton of steel)

Floor beams, etc	250
Heavy girders and columns	200
Trusses and purlins	400

As one-half gallon of paint and 1 hour of painters' time will be required for each 250 square-feet, per coat, it is evident that the cost per ton would figure out as follows, assuming the painters' rate at $1 and the paint at $1.50 per gallon:

1 hour painter	$1.00
½ gallon paint	.75
	$1.75

For heavy trusses, etc	$1.40 for each coat
For floor-beams, etc	1.75 for each coat
For trusses and purlins	2.80 for each coat

SECTION II. STEEL SASH

While there are several makes of steel sash on the market, all ordinary side-wall sash are made to the same dimensions, the glass sizes being

10 by 16,
12 by 18,
14 by 20,

for the full lights, the dimensions of lights in ventilators being 1 inch less on the outer edge, or frame, of the ventilator.

Thus, a six-light ventilator, consisting of two rows of three lights each, would be arranged thus:

(standard size of glass 14 by 20)

13 by 19	14 by 19	13 by 19
13 by 19	14 by 19	13 by 19

This variation of size need not be considered when taking f quantities for estimating or securing prices, but should e kept in mind when listing glass for purchase or shipment, nless it is planned to do the trimming at the building.

Different manufacturers have their own systems of de- ominating the various sizes of sash made by them but at used by the Detroit Steel Products Co. is the mplest and a list made on that basis will be perfectly ear to other manufacturers when embodied in a request r prices or an order for shipment.

In that system,

10 by 16 sized lights are listed as X
12 by 18 sized lights are listed as Y
14 by 20 sized lights are listed as Z
16 by 22 sized lights are listed as P.

The first figure written down is the number of lights in e width of the sash, the second figure is the number of ghts high, the third figure is the number of ventilators, the urth figure is the number of lights in each ventilator, nd the fifth figure is the number of rows under the ven- ator.

Thus, a list reading

3 sash—Z47–1–4–1
5 sash—Z47–1–4–4
2 sash—X55–1–6–1
2 sash—Y55

ould mean

3 sash for 14 by 20 glass, 4 lights wide, 7 lights high, 1–4-light ventilator, 1 row up from bottom.
5 sash, same size, 1–4-light ventilator, 4 rows of lights below ventilator.
2 sash, for 10 by 16 glass, 5 lights wide, 5 lights high, 6-light ventilator, 1 row up from bottom.
2 sash for 12 by 18 glass, 5 lights wide, 5 lights high, no ventilators.

When vertical or horizontal mullions are required, a proper notation should be made of them as, for instance, 3 windows, each consisting of 3 units 55-1-6-1 and 2 vertical mullions.

Catalogues of the sash manufacturers give full particulars as to over-all dimensions of all units.

Because sash prices vary constantly with the steel market and with other causes, it is not wise to use published price lists as a basis for estimating but a list should always be made and sent out for prices or else the plans should be sent and a lump-sum quotation received.

Where the work consists entirely of single units of steel sash, particularly in brick or cement-block walls, it is generally more economical for the builder to do his own erection, but where large openings are filled with "multiple-unit" sash, the trained organizations employed by the sash companies can show greater efficiency and it is always wise to get the sash companies' erection figures when possible.

In brick walls, it is practicable to set small sash in place (as is done with wood window frames) and to build the brick work up to the sash, but in concrete walls it is always necessary to leave rebates in the jambs and to set the sash later.

After the sash are set it is necessary to point or caulk around them, which is rather an expensive job, so now a patented metal rebate strip is being introduced which obviates this pointing.

Costs of erecting steel sash can be determined from the following tables:

TABLE LXXXII.—ERECTING STEEL SASH

(Hours per 100 square feet)

Single unit side-wall sash	8
Multiple unit side-wall sash	10
Monitor sash	11

TABLE LXXXIII.—POINTING STEEL SASH

(Hours per 100 linear feet)

rick jambs	2.5
oncrete jambs	4

The erection of single-unit sash can be handled by any en who are competent to determine when they are plumb nd straight but multiple unit and monitor sash are best andled by iron-workers who are experienced in setting sh.

Pointing of jambs is claimed by masons as their work ut can readily be done by handy laborers.

SECTION III. GLASS AND GLAZING

Estimating quantities of glass for steel sash work is a ery simple operation, since there is such a limited range glass sizes likely to be used and since the operation of sting the sash gives us a check on the total number of ghts required.

Thus, the simple multiplication of the number of units each denomination by the first two figures of the denomation gives the number of lights.

For instance, the item reading

3 sash—Z47–1–4–1
5 sash—Z 47–1–4–4
2 sash—X55–1–6–1
2 sash—Y55

ould be extended thus:

	Lights
14 by 20 glass (3) by 4 by 7	84
(5) by 4 by 7	140
	224
10 by 16 glass (2) by 5 by 5	50
12 by 18 glass (2) by 5 by 5	50
Total	324

If the glass is all of one kind, and if no distinction need be made of the sizes for ventilators, the quantities thus taken will be all that are required.

If, however, as is usual, the first two rows of glass are some grade of clear glass and the other rows are some grade of obscure glass, the necessary distinctions will have to be made in the list.

Care should be taken to specify exactly the same grades of glass in the list as are called for in the specifications as the substitution of glass only one grade poorer might create considerable trouble.

Glass manufacturers publish a list giving the stock sizes of all kinds of window glass, the number of lights packed in a box and the price per light or per box. These prices are subject to large discounts which vary considerably and it is essential either to get a price on your own glazing list or the latest discounts from the standard list.

A similar list is published for plate glass and it gives the details as to cost of bevelling, etc.

TABLE LXXXIV.—GLAZING STEEL SASH

(Hours glaziers' time per 100 lights)

Glass Size	Side Walls		Monitors	
	Summer	Winter	Summer	Winter
10 by 16	7	8	8	9
12 by 18	7	8	8	9
14 by 20	8	9	9	10
16 by 22	8	9	9	10
24 by 32			24	27
24 by 46			26	29
24 by 58			28	32
24 by 70			30	36

I have been told that the Union rules in some districts
nit the number of lights that may be glazed in steel sash
ork to one hundred per working day but I have seen
pert men put in two hundred or more lights day after
y. The table which follows is a safe one to follow since
e error, if any, is on the side of safety.

TABLE LXXXV.—PUTTY

NOTE.—For glazing in steel sash, "steel-sash putty" should be
ed. It is furnished by the manufacturer of the sash at a price
ually less than the cost of preparing it locally.

Pounds Putty per 100 Lights Glass

by 16	80	24 by 32	170
by 18	88	24 by 46	210
by 20	100	24 by 58	256
by 22	112	24 by 70	280

CHAPTER XI

LATHING, PLASTERING AND STUCCO WORK

SECTION I. WOOD LATHING

Until we get a great many more people to learn the plasterer's trade, plasterers will continue in much greater demand than the available supply and every building boom, or near boom, is going to see competition among builders for the plasterers than can be had. This always results in sending wages up and daily production down.

As long as such conditions last, any data submitted for the purpose of estimating plastering costs must be used with a great deal of judgment and due consideration of all existing local conditions.

The same remarks apply, though probably not with equal force, to metal lathing and furring.

Wood lathing, on the other hand, is usually paid for at an agreed price per 100 or 1,000 laths, so the lather has a definite incentive to do a good day's work. And if the price be known in advance, the estimator need only determine the number of laths needed and multiply it by the price to determine the labor cost of the work.

Since the laths themselves are purchased by the thousand, the following table will give all the information needed after the area to be covered has been determined.

The time given is for skilled lathers. When lathers are not available and the lathing is done by carpenters, the time must be increased from 25 to 33⅓ per cent depending upon the skill of the men employed.

Right here it is well to mention that trade practises in many communities affect the methods to be used in sur-

TABLE LXXXVI.—WOOD LATHING

Kind of Lath	Nailing Centers, Inches	Lath per Square Yard	Pounds Nails per 1,000 Lath	Hours Time per 1,000 Lath
inch wide, 32 inches long...	12	26.0	9	4.75
inch wide, 32 inches long...	16	26.0	7	4.50
inch wide, 48 inches long...	12	19.5	14	5.25
inch wide, 48 inches long...	16	19.5	10	5.0
⅜ inches wide, 48 inches long	12	19.0	14	5.25
⅜ inches wide, 48 inches long	16	19.0	10	5.0
½ inches wide, 48 inches long	12	14.5	14	5.25
½ inches wide, 48 inches long	16	14.5	10	5.0

ying quantities of lathing and plastering. For instance, certain sections no opening less than 21 square feet is ducted; in others, openings under 2 feet in width are t deducted and one-half of all wider openings is deducted. metimes curved work is charged at double the price of t work. Every estimator should familiarize himself with e practises in the sections in which he works and govern mself accordingly when considering work to be sub-let when undertaking work on a unit-price basis.

The data included in this discussion are, however, inded for the man who intends to employ the plasterers, hers and laborers himself and wishes to estimate accordly. He should take off actual net areas, and make the essary additions for corners and other items, as will be plained later.

Sometimes, plaster-boards are used as an effective subtute for the lath and for the first coat of plaster. In uring it should be remembered that the boards are made inches by 36 inches, so as to be suited for 12, 16 or 18-

inch nailings, and, therefore, each sheet contains only 8 square feet instead of a full square yard. Thus, if the boards are bought at 24 cents each, a yard costs 9/8 of 24 cents or 27 cents.

TABLE LXXXVII.—PLASTER BOARD

Thickness (Inch)	Weight per Yard (Pounds)	Nails per Yard (Pounds)		Square Yards Placed per Hour	
		12-Inch Nailing	16-Inch Nailing	12-Inch Nailing	16-Inch Nailing
¼	13.5	0.19	0.15	11	12
⅜	18.0	0.20	0.16	9	10
½	22.5	0.21	0.17	7	8

SECTION II. METAL FURRING AND LATHING

There is such a wide variety of kinds of metal lath that it is hardly practicable to tabulate accurately the unit time-costs of installing every kind of lath under all different conditions.

Figuring the cost of the lath itself is a simple matter since it is only necessary to take off actual quantities of surfaces to cover and add the following allowances for waste:

Plain surfaces, add 5 per cent
Beams, pilasters, etc., add 10 per cent
Cornices, add 20 per cent
Domed and groined work, add 25 per cent

Since quotations can be readily obtained on the kind of laths required, it is only necessary to multiply the quantity by the price.

The labor, however, will vary with the difficulty of handling the materials. Naturally, a heavier gauge cannot be manipulated as handily as a light gauge lath, and various types of expanded lath, even of the same gauge, will vary materially in their ease of manipulation.

For all ordinary work on wood furring, the following figures may be used, and 1 pound of staples should be included for each 20 square yards of lath.

TABLE LXXXVIII.—METAL LATH ON WOOD FURRING

(Hours per 100 square yards)

	Spacing of Studs or Furring (Inches)	Hours
lat ceilings	12	14
lat ceilings	16	10
Valls and partitions	12	12
Valls and partitions	16	9
imple coves	12	24
imple coves	16	18
imple cornices	12	26
imple cornices	16	20
laborate cornices	12	30 or more
laborate cornices	16	24
eams and girders	12	28
eams and girders	16	22
anel or arched ceilings	12	16
anel or arched ceilings	16	12
roined ceilings	12	18
roined ceilings	16	14

Where metal furring is required, except in the case of "self-furring" lath, it is necessary to calculate the amount

of furring material separately as it may vary from 5 pounds to the square yard in the case of comparatively simple cornice work, up to 15 pounds to the square yard in the case of heavy hung ceilings.

In doing this, it is necessary to take off all hangers, cross-bars and longitudinal bars and to figure their total weight by the method explained for builders' wrought-iron work, being sure to add 15 per cent for waste in cutting, bending, etc., and extend it at the current price per pound.

The labor cost of placing the material may be calculated from Table LXXXIX.

TABLE LXXXIX.—METAL FURRING AND LATHING

	Time in Hours per 100 Square Yards		Time in Hours per 100 Pounds Metal
	Placing the Lath		
	16-Inch Spacing	12-Inch Spacing	Placing the Furring
Simple beams	26	20	8
Heavy beams	30	24	9
Heavy cornices	32	26	9
Panelled ceilings	14	18	8
Groined ceilings	16	20	12
Flat ceilings	12	16	10
Partitions	11	14	3
Walls	11	14	5
Coves	20	26	8

SECTION III. PLASTERING

There is practically no limit to the number of different inds and qualities of plaster finishes that may be obained, each with a varying labor and material cost, and here is also a wide range of manufactured products available, each of different covering capacity and varying cost f application.

Manifestly, it will be impossible to discuss thoroughly ll of these finishes in this text, so we shall endeavor to reat only those which are in most general use.

Right here it may be well to add a word of caution to he estimator. It is not at all unusual to find a clause in pecifications stating that the work must be done in strict ccordance with all state and local regulations.

In certain places, local custom provides that not less han two coats of plaster must be applied, while in one tate there is a law requiring that all plastering must onsist of "scratch, brown and finish coats."

So, even though good mechanics can do a good job with nly one coat on "Sackett" board, or even though the pecifications require only one or two coats, it is necessary o figure upon putting on the number required by the egulations.

The man who has to estimate the cost of plastering hould familiarize himself with all of the various kinds of laster available in his market, their cost, covering capacy, workability, etc., so that he may make the most inelligent use of the information contained in this section.

In using the tables which follow, keep in mind that hey include the cost of all ordinary scaffolding but when he walls are over 12 feet high, it is usual to have the arpenters build a staging, which is often left in place or the use of the painters, or decorators, later.

Be sure that the estimate includes such staging under he proper heading.

If the patent plaster is bought in the prepared form, equiring no further addition of sand, simply mixing it with

water, a reduction of 1 hour of laborers' time may be made in any of the above figures for scratch and browning coats.

When using the table to prepare an estimate on a piece of plastering, be sure to take the proper figures for each of the coats required and add them together to get the total labor cost.

All of the figures in the table are for an ordinary "good" job of plastering. It is possible to reduce the time required, except for scratch coats, very appreciably if a good

TABLE XC.—LABOR COSTS OF PLAIN PLASTERING
(Per 100 square yards)

NOTE.—Figure an equal amount of hours of laborers' time to the number of hours of plasterers' time given in each case.

	Scratch Coats		Portland Cement
	Patent Plaster	Lime Plaster	
On brick	4.5	4.5	5.0
On hollow tile	4.5	4.5	5.0
On wood lath	4.75	5.0	5.5
On metal lath	5.25	5.5	6.0
On ribbed metal lath	6.5	7.0	7.5

	Browning Coats		
On scratch coat	7.0	7.5	9.0
On hollow tile	7.5	8.0	9.5
On brick	7.5	8.0	9.5
On Sackett board	7.0	7.5	9.0

	Finishing Coats	
	On Browning	On Sackett Board
White skim	8.5	9.0
Hard finish	9.5	10.0
Sanded white	10.0	10.5
Floated sand	11.0	11.5
Keenes cement	12.5	13.0
Caen stone	40.0	

ob is not wanted but it is well to ascertain definitely what ill be expected before cutting prices.

SECTION IV. ORNAMENTAL WORK

If any of the ornament required is such that it cannot e "run" in the ordinary manner, it is necessary to secure price from a shop having facilities for making plaster asts. These include dentils, egg-and-dart ornament, reaths, etc. etc., and must be planted onto the cornices or ther members which they ornament.

An allowance of 1 hour of plasterers' time should be ncluded for each 3 linear feet of "planted-on" ornaments nd each 2 square feet of panels, bas-reliefs or similar or-aments. This covers the setting only and does not include ny part of the cost of modelling or casting.

In figuring the labor cost of all ordinary "run" work, such coves, mouldings and rails, the simplest method that is all accurate is to measure the girth of the member, in-uding all the mouldings and figure it on the basis of the leveloped" area. It should be remembered, however, that

it takes as much time to run a moulding of 8 inches girth as it does one of 12 inches girth, so the girth should always be figured in full feet, when fractional dimensions occur. The full length should be taken, doubling for all corners and miters and the resultant area forms the estimating quantity.

TABLE XCI.—RUNNING ORNAMENTAL PLASTER

(Time per 100 square feet)

	Plaster	Keenes Cement	Portland Cement
Plasterers	20	24	48
Laborers	8	8	8

RULING TO IMITATE TILING

(Time per 100 square feet)

	Plaster	Keenes Cement	Portland Cement	Caen Stone
Plasterers	3	4	2	10
Laborers	¼	¼	¼	2

Bull-nosed Corners, Arrises, etc.

For all ordinary work add 8 hours plasterers' time for every 100 linear feet corners or arrises.

NOTE.—Portland cement finishes, whether of white or gray cement cannot be applied over any sort of gypsum undercoats. This is sometimes overlooked by specification writers and has often cost contractors appreciable sums of money because, while the finish will appear at first to be holding firmly, in a short time it will entirely separate itself from the backing.

Plastering Materials

TABLE XCII.—QUANTITIES PER 100 SQUARE YARDS

(Rough coats. Using wood lath)

	Sand (Yards)	Lime (Barrels)	Hair or Fibre (Bushels)	Patent Plaster (Pounds)	Cement (Barrels)
me mortar scratch	0 625	1.5	1.5	.....	.....
atent scratch	0.5	.....	.....	500	.....
ood pulp scratch	.....	.....	.....	700	.....
ortland scratch	1.20	0.7	1.5	.....	4.6
me mortar brown	0.875	1.5	1.0	.....	.....
atent brown	0.70	.....	.....	700	.....
ood pulp brown	.....	.....	.....	1,000	.....
ortland brown	1.20	0.7	1.0	.....	4.6

	Finish Coats			
	Plaster (Pounds)	Lime (Barrels)	Sand (Yards)	Portland Cement (Barrels)
im finish	30	1.5	.....	.....
ard finish	80	1.5	.....	.....
nded white	200	0.5	0.25	.....
nd floated	200	0.5	0.25	.....
eenes	300	0.5	.....	.....
en stone	2,500	.....	.....	.....
ortland cement	.....	0.5	0.62	1.60

When metal lath is used add 25 per cent to scratch-coat quantities.

If scratch coat is applied to brick, tile or plaster-board, deduct 30 per cent from tabular quantities.

Do not forget to figure the cost of elevator or hoist when estimating for a multi-story building.

SECTION V. STUCCO

The operations involved in stucco-work are essentially the same as those involved in interior plastering and, like plastering, it is impracticable to give complete cost data for all kinds within the limits of such a book as this.

The best results in stucco work are, however, usually obtained by workmen who specialize largely in that branch of the work and who have developed a technique that enables them to produce a quality of work far beyond that of the all-round plasterer.

Beside the ordinary kinds of cement-stucco, there are numerous patent or proprietary preparations on the market and, as with plasters, the estimator should obtain all possible data upon their use, covering capacity and workability from the manufacturers, as well as from persons who have used the preparations.

It is well to remember that, while they are undoubtedly actuated by motives of the purest intent, manufacturers are likely to be very optimistic about the cost of using their products, and sometimes results in actual practise are disappointing.

When getting information as to costs of applying different proprietary preparations, it is well to ask for details as to the quantity applied in a given time-period per man, the number of coats required and it should also be noted that some of these preparations require an especially prepared base for their successful use. Costs in dollars or cents per square yard are not very helpful unless all surrounding conditions are known.

Portland cement stucco is the most common stucco in general use (though magnesite stuccos are rapidly increasing

popularity) and it is probably also the most adaptable, nce it can be applied to almost any lath or masonry base, xcept that it can seldom be applied successfully to a con- rete surface that has not been thoroughly roughened and ashed.

Knowing the base to which the stucco is to be applied nd the number of coats required by the specifications, you n readily calculate the quantities of materials needed for ny ordinary stucco job from Table XCII.

Where the surface is to be enriched or "enlivened" by ne use of pebbles or crystals, it is necessary to add the ost of those materials, which are usually sold by the 100 ounds or by the ton by people specializing in that line.

Fine grit or crystals, allow 5 pounds per square yard.

One-fourth-inch pebbles, allow 20 pounds per square yard.

Intermediate sizes require proportionate amounts.

NOTE.—White Portland cement is much more expensive than dinary grey cement and white sand sometimes costs as much per shel as ordinary sand does per yard.

The labor costs of the scratch and brown coats, as may e required, can readily be calculated from the column in able XC headed "Portland cement."

Table XCIII gives the data for figuring the cost of a riety of finish coats, which are to be added to the cost of e rough coats.

TABLE XCIII.—LABOR COST OF STUCCO FINISH

(Hours per 100 square yards)

	Plasterers	Laborers
ain finish	12	9
nd float	15	11
arse pebble dash	16	12
ne pebble dash	16	12
ap-dash	15	11
oomed	15	11

CHAPTER XII

PAINTING AND PAPER-HANGING

SECTION I. GENERAL

As a general rule, because of the fact that the labor item in a painting estimate will amount to a great deal more i money than the material items will, and because the labo required to work around an opening is at least as much a that which would be required if there were no opening painters do not deduct openings when making estimates.

It is also quite customary to consider each linear foot o wood trim, when the actual width is a foot or less, as square foot, because there is very little difference in the tim required to cover a member a foot wide and a narrower on

On the other hand, there is a great difference in th amount of paint that will be used by different workmen depending upon how thoroughly they will brush out th paint and a day's work will also vary greatly with differen men.

SECTION II. MATERIALS

Of late, it has become more and more customary fo architects to specify well-known brands of ready-prepare paints because they feel more certain of the results they wi obtain than if they depend upon the painter's own judgmen in mixing and preparing the paint.

However, a great deal of paint is still mixed on the jo or in the painter's shop, and the estimator should have clear idea of the amounts of the ingredients needed to pr pare a given quantity of paint.

Table XCIV has been prepared for that purpose.

TABLE XCIV.—PAINT INGREDIENTS

(To make 10 gallons)

Paint	Linseed Oil (Gallons)	Turpentine (Gallons)	Drier (Pints)	White Lead (Pounds)	Enamel Varnish (Gallons)
hite primer	5.25	2.0	1.5	100	.....
cond coat	5.0	1.3	1.3	129	.....
nish coat	5.75	0.2	1.5	143	.....
side finish:					
Primer	4.5	2.3	1.7	114	.....
Second coat	4.3	1.4	2.1	143	.....
ll gloss finish	.....	.....	.....	30	9
g-shell	0.4	5.0	.....	167	.....
ad-flat finish	.....	5.2	.....	173	.....

o produce shades or colors add 3 to 15 pounds pigment to those quantities.)

The area of surface that can be covered by a given antity of paint depends, assuming that the same care is en in brushing out, upon the porosity of the surface, and o upon the temperature.

Of course, the first coat applied to any surface will be sorbed (except in the cases of metal surfaces) much more idly than the succeeding coats and thus a greater amount paint is required for the first coat than for the succeeding ats.

Mixed paint weighs approximately 15 pounds per gallon. White lead weighs approximately 36 pounds per gallon. In addition to the quantities of paints and varnish re- red, approximately a pound of putty must be used to h 1,000 square feet of surface.

TABLE XCV.—COVERING CAPACITY OF PAINTS

(Square feet per gallon)

Nature of Surface	Priming Coat	Other Coats
Smooth boards	500	700
Clapboards	450	630
Plaster	500	700
Brick	400	450
Stucco	425	500
Concrete	425	500

Notes.—New stucco or concrete surfaces must have their causticity neutralized. This can be done by the application of one coat of 1 to 9 solution of zinc sulphate in water.

TABLE XCVI.—COVERING CAPACITY OF VARNISHES, STAINS, ETC.

(Square feet per gallon)

	Hardwood	Softwood
Water-stain	700	600
Alcohol stain	400	350
Oil stain	550	550
Paste filler	300	300
Varnish	600	600
Shellac	700	700
Aniline stain	650	450
Floor varnish	500	500
Liquid filler	450	450
Kalsomine (on plaster)	.....	150

Where rubbing down is specified, the following materia are necessary, for each 1,000 square feet of surface.

5.6 pounds petroleum
1.2 gallons kerosene
3.5 pounds powdered pumice
10 pounds waste

SECTION III. LABOR

There is very little agreement in published data as to the nount of surface that a painter should cover in a day's

TABLE XCVII.—LABOR COST OF PAINTING

(Square feet covered per hour)

	Priming Coats	Finishing Coats
ıtside woodwork	200	220
apboards	180	200
ıtside trim	170	210
lling interior trim	80	.....
aining interior trim	175	.....
nd-papering interior trim	75	.....
ıbbing-down interior trim	75	.....
rnishing interior trim	.....	150
amelling interior trim	.....	120
lcimining plaster	350	180
inting brickwork	110	140
ling brickwork	110	140
inting concrete	110	140
inting plaster	110	140
ling floors	150	.....
axing floors	.....	200
lishing floors	.....	100
rnishing floors	.....	200
aining floors	180	.....
ncilling	.....	20

work. Some books give as wide a variation as from 20 to 180 square feet per hour.

Of course, such data are obtained by taking the average of entire jobs, rather than by recording the performance on each different kind of work. Obviously, some kinds of work require a great deal more time than others, and the proper procedure is to determine the production that may fairly be expected.

In Table XCVII the quantities given are those that can reasonably be considered as a fair average production.

This may seem to be rather a brief method of treating the entire subject of estimating the cost of painting, yet there is hardly any ordinary specification, that will be encountered by a building contractor, that cannot be resolved into its component parts and estimated by means of the tables given in this chapter.

Example.—Assume a building, for which the following areas to be covered have been computed.

14,000 square feet 2 coats mill-white on ceilings.
6,500 square feet 3 coats mill-white on brick walls.
2,400 square feet 2 coats graphite paint on steel sash.
1,800 square feet 2 coats white paint on cornices.
14,000 square feet 2 coats cement coating on cement floors

The cost of the materials would be as follows:

$\frac{14,000}{500}$ = 28 gallons mill-white for first coat on plank.

$\frac{14,000}{700}$ = 20 gallons mill-white for second coat on plank.

$\frac{6,500}{400}$ = 16.25 gallons mill-white for first coat on brick.

$\frac{6,500}{450}$ = 14.5 gallons mill-white for second coat on brick.

14.5 gallons mill-white for third coat on brick.

93.25, say 94 gallons mill-white.

(The steel sash should be figured according to Chapter X.)

$\frac{2,400}{500}$ = 4.8 gallons per coat or 9.6 gallons say 10 gallons
aphite paint.

$\frac{1,800}{500}$ = 3.6 gallons for first coat on cornice.

$\frac{1,800}{700}$ = 2.6 gallons for second coat on cornice.
6.2 gallons, say 7 gallons white paint.

$\frac{14,000}{425}$ = 33.0 gallons for first coat on floor.

$\frac{14,000}{500}$ = 28 gallons for second coat on floor.
61 gallons cement coating.

ilings 14,000 square feet.
rnices 1,800 square feet.
15,800 square feet. Priming coats on wood.

ilings 14,000 square feet.
rnices 1,800
15,800 square feet. Finishing coats on wood.

$\frac{1,800}{200}$ = 79 hours priming wood.

$\frac{15,800}{220}$ = 71.9 say 72 hours finishing wood.

$\frac{6,500}{110}$ = 59 hours priming brick.

$\frac{\text{by } 6,500}{140}$ = 93 hours finishing brick.

$\frac{\text{by } 2,400}{250}$ = 19.2, say 20 hours on steel sash.

$\frac{14,000}{110}$ = 127 hours priming floor.

$\frac{14,000}{140}$ = 100 hours finishing floor.

Total . 550 hours.

Summary

94 gallons mill white at $1.75	$164.50
10 gallons graphite paint at $2.25	22.50
7 gallons white paint at $2.50	17.50
61 gallons cement coating at $1.50	91.50
550 hours labor at $0.85	467.50
Insurance	23.72
Contingencies, including brushes, etc.	50.00
Cost	$837.22

Under ordinary circumstances, the profit to be added by the painting contractor should bring the figure up to about $1,000.

SECTION IV. PAPER-HANGING

On new work, it is necessary to prepare the plastered walls by giving them a coat of glue sizing before applying the wall paper. The amount of size required will vary with the smoothness and porosity of the wall, but average quantities are

0.10 gallons size per 100 square feet.
0.25 hours labor per 100 square feet.

The ideal method of paying for paper and paper-hanging is on the basis of the number of rolls actually required and used. It is then only necessary to calculate the number of rolls of each kind of paper required and to multiply by the proper prices per roll.

Prices of paper vary all the way from 15 cents to several dollars per roll and it is, therefore, necessary to get the correct prices for the papers specified.

A single roll is 18 inches wide by 24 feet long.
A double roll is 18 inches wide by 48 feet long.
Some high-grade papers are made 30 inches wide by 15 feet long.

For all ordinary purposes, the best method of estimating the number of rolls required is to multiply the perimeter

the room by its net height (from top of base-board to rder or ceiling) and then deduct the net size of any doors d windows.

Dividing the area thus calculated by 36 square feet, we the net number of standard single rolls required.

If the paper has no figured pattern, 5 per cent should be added.

If the paper has a small figured pattern, 10 per cent should be added.

If the paper has a large figured pattern, 15 per cent should be added.

These additions will cover necessary waste in trimming d matching.

Ceiling areas are figured in the usual manner and the mber of rolls determined by dividing as above.

The number of rolls that can be applied in a day's work pends a great deal upon the weight of the stock and some- at upon the pattern, the figures given in Table XCVIII ver ordinary conditions.

TABLE XCVIII.—PAPER-HANGING

(Single rolls per hour)

	Light	Medium	Heavy
alls	5	3.5	2.5
ilings	4	3.0	2.0
lls per gallon paste	12	8.0	6.0

Borders are figured by the linear yard and a given length border will require the same amount of labor as a corponding length of wall paper.

CHAPTER XIII

ROOFING AND SHEET METAL. DAMP PROOFING AND WATER-PROOFING

SECTION I. COMPOSITION ROOFING

There are as many different kinds of composition roofing as there are manufacturers of roofing felts and cements, and each varies slightly from the other in the amount and cost of materials, as well as the labor cost of application. It is, therefore, practically impossible to discuss each kind of roof in detail.

However, there are a few well-established types and a discussion of them will develop the method of estimating so that, by an examination of the specifications in each case the estimator can determine the quantities of materials and labor required.

Those general types are

Tar and gravel, or tar and slag,
Asphalt,
Asbestos.

The common unit of measurement of roofs is the square of 100 square feet and all of the quantities are given here on that basis.

All of these types of roofs are usually applied by companies who specialize in roofing and who are prepared to guarantee their work water-tight for periods ranging from 5 to 20 years, depending upon the thickness of the roof applied.

Some of these roofs, such as the J.M. asbestos, are only plied by the manufacturers, while others, the Barrett for tance, are applied by approved roofing contractors and aranteed and bonded by the manufacturers of the ma- ials.

The tables which follow give the quantities of materials quired for 1 square of roof.

TABLE XCIX.—TAR AND GRAVEL ROOFS

(Materials per square on wood decks)

Name	Pounds Rosin-Sized Paper	Pounds Felt	Pounds Pitch	Pounds Gravel
year Barrett				
ply)	5	60	125	400
year Barrett				
ply)	5	75	150	400
ly Irvin	5	75	150	400
ly 15 pound felt	5	75	125	400
ly 15 pound felt	5	60	100	400
ly 15 pound felt	5	45	75	400

On concrete decks

year Barrett	60	175	400
year Barrett	75	200	400
ply Irvin	75	180	400
ply 15 pound felt	75	150	400
ply 15 pound felt	60	135	400
ply 15 pound felt	45	110	400

If slag is used, only 300 pounds will be required.

TABLE C.—ASPHALT ROOFS

(Materials per square on wood decks)

	Pounds Rosin-Sized Paper	Pounds Felt	Pounds Asphalt
2-ply		55	60
3-ply		70	90
4-ply		85	120
5-ply	5	75	120

For concrete decks, omit any rosin-sized paper and add 10 pounds asphalt primer.

TABLE CI.—ASBESTOS ROOFS

(Materials per square on wood decks)

	Pounds Asbestos Felt	Pounds Asphalt
3-ply	60	81
4-ply	73	90

For concrete decks, add 10 pounds asphalt primer.

The times given in the table are for wood decks, for concrete decks add 0.25 hour per square.

The tabular times must be increased 20 per cent for winter work and 0.125 hour per square for each 12 feet beyond the first 25 feet that the materials must be hoisted

TABLE CII.—LABOR ON COMPOSITION ROOFS

(Hours per square)

	2-ply	3-ply	4-ply	5-ply
rrett	.....	.....	1.75	2.25
in	.....	.....	.....	1.50
-pound felt, tar and gravel	1.00	1.25	1.50	1.75
phalt	1.25	1.50	1.75	2.00
bestos	.....	.....	1.50	1.75
ady-roofing	0.75	.....	.....	.....

Prices on the pitch, felt, asphalt and asbestos will usually quoted on the basis of a ton, while the slag or gravel will quoted either by the ton or the cubic yard.

The cost of hauling the materials from the railroad to the e of the work can be calculated as explained for other terials in previous chapters and, besides including the urance, an item of 5 per cent of the net cost should be luded to cover miscellaneous items such as mops and all contingent expenses.

Where promenade tiles are required, in addition to the st of the roof, it will be necessary to add

For 6 by 9 Tile	For 6 by 6 Tile
0 pounds composition	300 pounds composition
ours roofers' time	10 hours roofers' time
ours laborers' time	8 hours laborers' time

well as the cost of purchasing, delivering and hoisting the es.

SECTION II. SLATE AND ASBESTOS SHINGLES

Roofing slates are sold by their producers at certain prices per square (sufficient slate to lay 100 square feet with standard 3 inch lap) and extra charges are made for punching and counter-sinking.

There is a wide variety of kinds, sizes and grades of slates and prices vary, according to recent lists, from $6 to $24 per square for slates of ordinary thickness, and up to $70 per square for slates 1½ inches thick.

As a general rule, larger sizes of slates cost less per square than the same grade in smaller sizes and, because of the smaller number required, the labor is also less.

The estimator who has occasion to figure upon slate roofs should obtain current price lists from the producers and should also keep informed as to the differentials that are charged on less than carload orders, as well as the extras for punching and counter-sinking.

Ordinary slates will average 650 pounds per square and cartage can be figured on that basis. An average of ½ hour laborers' time will cover the cost of unloading from car to truck and ⅓ hour from truck or wagon.

In addition to the times given in Table CIII, it is necessary to add ½ hour roofers' time per square for laying the felt under the shingles.

The times given in the table are sufficient to include all ordinary scaffolding but an addition of ½ hour per square must be made for all curved surfaces and ⅓ hour per linear feet for all hips and valleys.

Asbestos shingles are made in a variety of sizes and colors and hip- and ridge-roll of the same material are usually used. If the shingles are laid in "American" style the cost of laying will be the same as for similar sizes of slate, but if they are laid in the "hexagon" or "diagonal method" the number used will be less and a saving of ½ hour slaters' time and ¼ hour helpers' time will be made.

Wood shingles and asphalt shingles are discussed in Chapter VIII.

TABLE CIII.—SLATE ROOFS

Size	Number per Square	Pounds Nails per Square	Slaters' Time per Square	Helpers' Time per Square
by 10.....	695	6.25	2.8	2.0
by 12.....	534	5.30	2.6	2.0
by 12.....	457	4.70	2.2	2.0
by 14.....	374	3.75	2.1	2.0
by 10.....	514	4.00	2.2	2.0
by 12.....	400	3.80	2.1	2.0
by 14.....	328	3.25	2.1	2.0
by 16.....	277	2.75	2.1	2.0
by 14.....	295	3.00	2.1	2.0
by 16.....	247	2.50	2.0	1.8
by 18.....	214	2.10	2.0	1.8
by 14.....	262	2.60	2.4	2.0
by 16.....	222	2.25	2.2	2.0
by 18.....	192	1.90	2.0	1.8
by 20.....	170	1.75	2.0	1.8
by 16.....	204	2.00	2.0	1.8
by 18.....	176	1.75	2.0	1.8
by 20.....	156	1.60	1.9	1.5
by 22.....	138	1.50	1.9	1.5
by 16.....	185	1.80	2.1	1.8
by 18.....	160	1.60	2.0	1.8
by 20.....	142	1.50	2.0	1.8
by 22.....	127	1.25	1.9	1.5
by 24.....	115	1.20	1.9	1.5
by 22.....	116	1.20	1.9	1.5
by 24.....	107	1.10	1.6	1.5
by 20.....	121	1.25	1.9	1.5
by 22.....	105	1.10	1.6	1.5
by 24.....	98	1.00	1.5	1.5

SECTION III. TILE ROOFS

Cement-tile roofs of the "Federal" and "American" types are usually laid by the manufacturers under a guaranty and, since prices vary greatly with conditions, the estimator should always submit the roof plan and specifications directly to the manufacturers for their estimates.

Clay-roofing tiles may either be installed directly by the manufacturers or their representatives, or sold to the roofing contractor and installed by him. Flat, or "promenade" tile were discussed in Section I.

Clay tiles are made in "Spanish," "Mission," "Shingle" and "Imperial" types, and special ridge-rolls, hip-rolls, finials, starters, etc., are made for each type. This makes it necessary either to list the pieces carefully or to send the plans to the manufacturers and have them make a price on the entire lot.

The labor of laying and handling will be 1.5 times that of similar sizes of slates and the cartage is figured on the basis of 1,000 pounds per square for ⅜-inch shingle tile, 1,350 pounds per square for ½-inch shingle tile, 800 pounds per square for Spanish or Mission Tile.

All tile roofs (except those types which attach directly to steel purlins) must be laid over a course of 40-pound asphalt felt.

Spanish and Mission Tiles also require 90 feet of 1 by 2 furring strips and 14 laths per square.

Shingle tiles require the laths but not the furring strips.

SECTION IV. METAL ROOFS

Tin plates are furnished in a variety of grades, dependent upon whether the base stock is steel or charcoal-iron, and upon the quality and weight of the coating. Prices are quoted by the box, which contains 112 sheets of one of the following sizes:

10 by 20
14 by 20
20 by 28

the last two being the most commonly used.

The roof may be laid either with flat or standing seams. The cost of a comparatively flat tin-roof may be figured n the basis of Table CIV, but no deductions should be ade for small openings.

TABLE CIV.—TIN ROOFS

(Materials required per square)

	14 by 20 Size Tin	20 by 28 Size Tin
heets tin	62	29
ounds solder	8	5
ounds nails	4	3
ounds rosin	1	1
ounds charcoal	2	2
ours labor	7	5

Painting of the under side of the sheets, as well as cart-ge of materials to the work, must be estimated according the methods previously explained and added to the timate.

If standing-seam roofs are specified, the items of solder, sin and charcoal are omitted from the estimate but the uantities of tin are:

	14 by 20 Size	20 by 28 Size
ams on short edge	66	31
ams on long edge	68	32

Copper roofing is always specified by the weight in ounces r square foot of the sheet copper to be used and the eight of material is thus readily figured. Five per cent

will cover the waste on all ordinary copper roofing and the labor and other items will be the same as for tin.

Stamped metal shingles, tin-plate, galvanized or copper, require the same amount of labor as for slate-shingles of corresponding sizes and, in addition, both sides of the tin-shingles must be painted, as must also the upper-side of the galvanized shingles; though the painting of exposed surfaces may be included in the painters' specifications.

SECTION V. SHEET-METAL WORK

Ordinarily, gutters, leaders, hip-roll, ridge-roll and finials are purchased ready-made from manufacturers and it is only necessary for the builder to obtain prices on them and to calculate the cost of erection.

Gutters will be made of tin, copper, galvanized iron or zinc and will require bending to shape and installation. The specifications will determine the kind and weight of material, as well as its width, to be used. The same remarks apply to flashing.

After finding the cost of the materials, the labor cost of installation can be determined by figuring that a mechanic and helper will erect 15 linear feet an hour of hanging gutters, leaders, hip-roll, ridge-roll, base-flashing or cap-flashing.

Stepped flashing around chimneys and in similar locations can be figured on the basis of 6 linear feet per hour.

To attempt to cover the estimating of all such items of sheet-metal construction as cornices, skylights, windows, etc., would demand an entire volume in itself. Therefore, no attempt is made to discuss them here and the estimator is advised always to secure a figure from a manufacturer who is properly equipped to turn out the work.

SECTION VI. DAMP-PROOFING

The common methods of damp-proofing consist essentially of painting the concrete or masonry surfaces with a

ıter-proof or water-resisting paint or compound. Damp-oofing is distinguished from water-proofing in that damp-oofing is not intended to resist water pressure.

Most damp-proofing paints have an asphaltic base and eir covering capacity varies greatly with their consis-ıcy (which also varies greatly with the temperature) and e roughness of the surface to which they are applied.

At temperatures of 60 degrees Fahrenheit and upward, e figures in Table CV will apply for most of the com-unds, but at lower temperatures the covering capacity ll decrease rapidly and few of them can be satisfactorily plied at all when the temperature is below freezing.

TABLE CV.—DAMP-PROOFING

(Asphaltic compounds or paints)

Nature of Surface	Average Covering Capacity in Square Feet per Gallon	Hours Required to apply 1 Gallon
ıgh concrete...	75	1.0
ıooth concrete..	125	1.2
ickwork.....	75	1.0
llow-tile.....	60	1.0
ne.....	125	1.5
od.....	250	1.4

Damp-proof paints can be applied by any laborer with fficient intelligence to make sure that the entire surface covered.

Example.—Required, the cost of damp-proofing 1,000 ıare feet of brickwork, with a compound costing $1.80 r gallon and labor at 50 cents per hour.

Compound	$1.80	
Labor	.50	
	75)2.30	
	.037 per square foot or	$37.00
Allow for brush, etc.		1.50
Insurance on pay roll		.30
Contingencies		1.90
		$40.70

SECTION VII. WATER-PROOFING

Water-proofing methods fall into three general classes, as follows:

Membrane water-proofing, consisting of a number of plies of saturated felt or burlap, coated over and between with pitch or asphalt.

Integral water-proofing, consisting of the addition of water-proofing materials to the cement or the mixing water that is used for making concrete.

Plaster-coating, consisting of the application of a coat, from ½ inch thick upward, of water-proofed cement plaster to the brick or concrete walls and floors.

Some of the water-proofings in the last two classes are applied only by the manufacturers, or their representatives, and it is always necessary to get their figures.

The other preparations are sold by the pound or gallon and the amount to be used varies with each compound, so it is necessary to obtain detailed information in each case, and estimate accordingly.

Usually the amount to be used is a certain number of pounds per bag of cement, and the procedure for estimating is the same as outlined in Chapter VI, but precaution must be taken to estimate the cost of caring for water as mentioned below.

The engineer or architect should specify the number of plies of felt or burlap to be used, when membrane water proofing is required, also the weight per square of the fel

burlap, the kind of composition to be used for coating, d the number of pounds of coating per 100 square feet r application.

Since there will be one coating of pitch or asphalt on ch side of each ply of the membrane, it is evident that ere will always be one more coating than the number plies.

Thus, if 7-ply water-proofing is required, with 40-pound ating per application, each square would require,

320 pounds composition and
770 square feet felt or burlap.

per cent being allowed for lapping and waste and, if e felt weighs 26 pounds per square, its weight would be 0.2 pounds.

In computing the area to be covered, it is necessary to clude all bends, angles, returns and key-ways before ding the percentage for waste.

The labor of applying the water-proofing will require average of 0.8 hours per square for each ply of membrane and the same amount for each coating of composition.

Thus, the 7-ply water-proofing mentioned above would quire

for placing felt, 7 plies @ 0.8	5.6 hours
for placing composition, 8 coatings @ 0.8	6.4
	12.0 hours
and at 75 cents per hour this would be	$ 9.00
adding 302 pounds composition @ $35 per ton	11.20
201 pounds felt @ $19 per ton	3.82
Insurance	.45
Contingencies, including mops and fuel	2.25
Net cost per square	$26.72

Thus, the calculation of the cost of the actual water-proofing is a very simple matter, but the cost of caring water during construction is often a much more serious

matter than is the application of the water-proofing, and it is practically impossible to give any rules that may be followed.

For this reason, it is recommended that all water-proofing problems be referred to one of the sub-contractors specializing in that work and whose experience has taught them how to cope with almost any conditions that may be encountered.

CHAPTER XIV

SHORT-CUT METHODS OF ESTIMATING

SECTION I. GENERAL

To the best of my knowledge, the methods of preparing preliminary estimates for Mill buildings as outlined in this Chapter, were first proposed by Charles T. Main, Engineer, of Boston, Massachusetts, in a paper which he presented at a meeting of the New England Cotton Manufacturers' Association, April 28, 1904.

The method outlined is vastly superior to any attempt to estimate contents by the square-foot or cubic-foot method and its greater accuracy well compensates for the added time required for its use.

The superiority of this method lies in the fact that it takes into consideration the variation in the ratio of floor area to wall area that takes place with every increase in the size of a building or any change in its shape.

An exaggerated comparison, but one that brings out forcibly the principle involved, is as follows:

Dimensions	Area	Length of Wall	Ratio of Length of Wall to Area of Floor
1 by 1.....	1	4	4 to 1
0 by 100.....	10,000	400	4 to 100
2 by 1.....	2	6	3 to 1
0 by 100.....	20,000	600	3 to 100
3 by 1.....	3	8	2 2/3 to 1
0 by 100.....	30,000	800	2 2/3 to 100

However, like the "cubic-foot of contents" or "square-foot of area" method, the method given here is suitable only for approximate estimating and is not a safe method to use for bidding.

But, if this method is used with the proper care, always working out unit prices on the basis of up-to-date costs, there should be no trouble in quickly making an approximate estimate on any reasonably standard building and the estimate should fall within the range of the figures actually submitted in competition.

SECTION II. MILL-BUILDINGS

Assuming the following data as approximately the average, or standard, of mill-buildings in a given territory, we can proceed to set up a series of unit costs of a linear foot of wall construction and a square foot of floor or roof construction.

Floor timbers, 12 by 16, LLYP, 8–0 center to center
Floor planking, 4 inches, LLYP, splined
Roof planking, 3 inches, LLYP, splined
Roof timbers, 8 by 14, LLYP, 8–0 center to center
Roof covering, 5-ply tar and gravel
Finished floors, 13/16 maple
Floors on earth, 4-inch tar-rok, 3-inch hemlock plank and 13/16 maple, or 3-inch concrete base course and 1-inch top-coat
Foundation, concrete, 4 inches thicker than wall it supports and 4–0 total height from top of footing to top of water table.
Footing course, concrete, 10 inches thick by width 8 inches greater than foundation course
Story heights, 12–0 floor to floor
Wall thickness, as per table:

Now, assuming that we have found, by the methods out

TABLE CVI

ight of uilding Stories	Thickness of Brick Walls in Inches									
	Outside Walls					Inside Walls				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1	12	....	....	....	....	12	....	....	....	....
2	12	12	....	....	....	12	12	....	....	....
3	16	12	12	....	....	12	12	18	....	....
4	20	16	12	12	....	16	12	12	8	....
5	24	20	16	12	12	20	16	12	12	12

d in previous papers, that we may use the following as rage costs:

Bricks, delivered to the site, per thousand	$22.00
Mortar, per thousand bricks	4.00
Labor, per thousand bricks	26.00
Insurance, etc	2.60
Profit	5.40
Cost of bricks in walls, per thousand	$60.00

allowing 21 bricks to the cubic foot, the cost per square of wall will be as follows:

TABLE CVII

nch wall	$0.84 per square foot
nch wall	1.26 per square foot
nch wall	1.68 per square foot
nch wall	2.10 per square foot
nch wall	2.52 per square foot

and, therefore, a linear foot of all would be figured as follows:

TABLE CVIII.—UNPIERCED WALLS

Height of Building	Outside Walls	Inside Walls
1 story	$ 15.12	$15.12
2 story	35.28	30.24
3 story	50.40	40.32
4 story	75.60	60.48
5 story	105.84	85.68

The figures just given are for unpierced walls, but most mill buildings have fairly large windows at regular intervals. Since steel sash are popular at present, let us consider that each 8-foot bay of the building is lighted by a standard steel sash Y-55-1-6-1.

The size of the opening is, therefore, 5 feet 2¾ inches by 7 feet 8¾ inches, or 40.4 square feet, and we will assume its cost to be

Sash	$ 8.50
Erection	2.50
Glass	12.50
Glazing and putty	3.00
Pointing	1.50
Stone sill and setting	4.00
Profit and insurance, etc.	4.00
	$36.00

Since the bays are 8 feet 0 inches from center of window to center of window and the story heights are 12 feet, each bay, or panel, of wall will contain 96 square feet, consisting of

40.4 square feet of window and
55.6 square feet of brick work

om which we calculate that a bay of 12-inch wall would
ost

For window, as before	$ 36.00
55.6 square feet wall @ 1.26	70.06
	$106.06

practically $13.20 per linear foot.

TABLE CIX.—PIERCED WALLS (STEEL SASH)

Height of Building	Cost per Linear Foot of Wall
1 story	$13.25
2 story	29.43
3 story	42.68
4 story	61.77
5 story	83.68

A similar table can be prepared for varying lengths of ays and kinds and sizes of windows, and the estimator ho has frequent occasion to furnish preliminary esti- ates can well afford to utilize any spare time that he ay have in preparing a series of such tables to cover the ariety of conditions he most frequently encounters.

Foundations.—From the assumptions previously made, is evident that the foundation sizes will be as follows: Since the height of the footing and foundation courses taken to be the same in all cases, we shall always re- ire practically 10 square feet of forms to each linear ot of wall.

Assuming that, by the methods outlined in previous apters, excavation, either back-filled or wasted, costs .00 per cubic yard.

Concrete, in place, costs $16.00 per cubic yard.

Forms cost 16 cents per square foot

TABLE CX.—FOUNDATIONS FOR OUTSIDE WALLS

Building Height	Footing Course	Foundation Course	Cubic Yard Concrete per Linear Foot	Cubic Yard Excavation per Linear Foot
1	2–0 by 0–10	1–4 by 4–0	0.26	0.5
2	2–4 by 0–10	1–8 by 4–0	0.32	0.55
3	2–4 by 0–10	1–8 by 4–0	0.32	0.55
4	2–8 by 0–10	2–0 by 4–0	0.39	0.6
5	3–0 by 0–10	2–4 by 4–0	0.44	0.65
		FOUNDATIONS FOR INSIDE WALLS		
1	2–0 by 0–10	1–4 by 4–0	0.26	0.5
2	2–0 by 0–10	1–4 by 4–0	0.26	0.5
3	2–0 by 0–10	1–4 by 4–0	0.26	0.5
4	2–4 by 0–10	1–8 by 4–0	0.32	0.55
5	2–8 by 0–10	2–0 by 4–0	0.39	0.6

we can construct another table, as follows; allowing for profit and insurance.

TABLE CXI.—COST OF FOUNDATION

Building Height	Per Linear Foot Outside Walls	Inside Walls
1	7.15	7.15
2	8.30	7.15
3	8.30	7.15
4	9.65	8.30
5	10.60	9.65

Floor Constructions.—Floors resting directly upon the earth will not have any parts of the structural frame included in their cost, but must bear all of the cost of removing top-soil, grading, cinder or gravel fill, or similar items.

Assuming the square of 100 square feet as the basis of calculation for this type of floors, we may use the following figures:

CONCRETE FLOOR:

Excavating top-soil 3.7 cubic yards @ $1.00	$ 3.70
Levelling sub-grade	2.00
2.09 barrels cement @ $3.20	6.69
0.70 yards sand @ $1.50	1.05
0.85 yards gravel @ $2.50	2.13
Labor on base and top courses	9.0
Insurance and Profit	3.0
Cost per square	$27.57

or, 28 cents per square foot.

TAR-ROK, HEMLOCK AND MAPLE FLOOR:

Including grading usually sub-let for about	$15.00
300 FBM hemlock plank @ $45	13.50
Labor placing plank	3.00
Floor paper	.50
130 FBM maple @ $90 per M	11.70
Labor placing maple	4.00
Nails, etc.	.50
Insurance and Profit	5.00
Cost per square	$53.20

or, practically, 54 cents per square foot.

Floor constructions, as well as roof constructions, which are supported by the structural frames must bear the cost of their share of the structural frame, and it therefore becomes easier to figure the cost on the basis of the bay or panel, instead of the square.

In order not to make our list of units unduly compli-

cated we will make certain assumptions which, while not absolutely true, give fairly close results.

We will assume the spacing of beams to be 8 feet 0 inches center to center, the spacing of columns longitudinally to be 18 feet 0 inches center to center, the average column to be 10 by 10, 12 feet 0 inches long, the average share of column footing to each story to be equal to one 24 by 24 by 18 footing.

Then, for one bay, we must allow

0.9 cubic yard excavation	@ $ 1.00	$ .90
0.23 cubic yard concrete	@ 16.00	3.68
12 square feet forms	@ .16	1.92
1 10 by 10/12–0 column,	100 FBM	
1 12 by 16/18–0 beam,	288 FBM	
4-inch plank,	662 FBM	
	1,050 FBM average 70.00	73.50
Miscellaneous iron, pintles, etc., 200 pounds		10.00
Splines 216 linear feet @ 1 cent		2.16
Nails and Paper		1.50
Labor on timber @ $18.00		6.90
Labor on plank @ $4.00		5.76
167 FBM maple @ $90.00		15.03
Labor placing maple		5.76
Insurance and profit		20.00
Cost per panel of 144 square feet		$147.20

or practically $1.03 per square foot.

For the roof construction, we would allow the same figures for the first three items, but must take into consideration the over-hang of the roof and the cost of the cornice.

Since the corner panels of the roof carry over-hang and cornice on two sides, while the center panels do not carry either, we are safe in figuring each panel as though it carried an 18-inch over-hang and full cornice on one side, which also means that our timber must be figured as 20 feet long; thus,

Excavation, concrete, forms		$ 6.50
Column,	100 FBM	
1 8 by 14/20 beam,	187 FBM	
3-inch plank,	552 FBM	
	839 FBM @ $70.00	58.73
Misc. iron (hangers, etc.)		10.00
Splines, hails, etc.		2.60
Labor on Timber @ $18.00		5.16
Labor on plank		5.76
Roofing (sub-let for $15.00 per square)		21.00
Insurance and profit		14.00
Cost per panel		$123.75

or, practically 86 cents per square foot of building, disregarding the overhangs.

Miscellaneous Items.—By the usual methods, we may estimate the cost of such items as flights of stairs, and find that the average will be about $180 per flight for ordinary mill stairs and $235 per flight for an outside iron fire-escape.

From previous experience, we can determine an average cost per fixture for the plumbing, and this will probably be about $100.

Painting costs vary widely, depending upon the amount of work that is required and the kinds of materials to be used, but an allowance of 5 per cent of the combined costs of the mason and carpenter work will be sufficient for a preliminary estimate.

Ornamental stone trim, tile floors and similar items should be figured on the basis of prices paid for similar recent jobs and added to the figures determined according to this method.

Profit and insurance have already been included, but an additional allowance of 10 per cent should be added to the estimate to include any incidentals that would otherwise be overlooked.

Assuming that a request has been received for a preliminary estimate to cover a cotton mill. It is to be five-

stories high, to be of standard mill-construction and is four hundred feet long, sixty feet wide, divided by a cross wall at the middle of the length and each end of each floor has a stair enclosure 12 by 16 feet and a toilet room enclosure of the same size, with six fixtures in each.

The length of the outside walls is evidently 920 feet, the length of the inside walls is

Cross Walls	60
Partition Walls (4) by 28	112
	172 feet

ESTIMATE.

1. 172 linear feet Fdtn of 5-story inside wall @ $9.65	$ 1,659.80
920 linear feet Fdtn of 5-story outside wall @ $10.60	975.20
2. 172 linear feet 5-story inside wall @ $85.68	14,736.96
920 linear feet 5-story outside wall @ $83.68	76,985.60
3. 24,000 square feet tar-rok, hemlock and maple floor @ $54	12,960.00
4. 96,000 square feet standard floor @ $1.03	98,880.00
5. 24,000 square feet standard roof @ $80	20,640.00
6. Painting 5 per cent of items 2–3–4–5	11,210.10
7. Stairs 8 flights @ $180	1,440.00
8. Plumbing 60 fixtures @ $100	6,000.00
9. Contingencies	25,986.00
Total	$ 271,473.66

which equals $2.26 per square foot of floors or $0.188 per cubic foot of building. If the principal units have been correctly calculated upon the basis of current prices, the figure should invariably come between the highest and lowest figures submitted when the plans are sent out for actual competitive bids.

SECTION III. REINFORCED CONCRETE BUILDINGS

Reinforced concrete buildings generally fall into one of two general types, flat-slab construction and beam and

girder construction but, because the flat-slab construction is rapidly superseding the other type for industrial buildings, we will only attempt to draw up figures for the first type.

There are several different "systems" of flat-slab construction, but for equal spans and equal loadings the costs do not vary a great deal, so only one set of figures will be needed for preliminary estimating.

The two important factors governing the costs of reinforced concrete factory buildings are the live-floor load, which determines the slab-thickness and percentage of steel, and the column spacing.

Column spacings vary appreciably but a dimension of 20 feet 0 inches center to center is sufficiently standard to warrant its use in determining slab-thicknesses and steel-percentages, and from them the approximate costs per square foot of slab.

From the "Concrete Designers' Manual," by Hool and Whitney (McGraw-Hill Book Co., New York City), we get the following quantities of steel and concrete for slabs (including drop-heads) designed according to the recommendations of the American Concrete Institute.

TABLE CXII.—FLAT SLAB FLOORS

(Panel size 20 by 20 feet)

Live Load per Square Foot (Pounds)	Concrete per Square Foot (Cubic Foot)	Reinforcing Steel per Square Foot (Pounds)
100	0.65	2.53
150	0.65	3.27
200	0.70	3.70
250	0.74	4.00
300	0.81	4.30
350	0.86	4.55

TABLE CXIII.—AVERAGE SIZES OF COLUMNS

Height of Building in Stories	Diameters of Interior Columns					Thickness of Exterior Columns (Width Assumed 16 Inches)				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1	12	....	....	....	....	12	....	....	....	....
2	14	12	....	....	....	12	12	....	....	....
3	16	14	12	....	....	14	12	12	....	....
4	18	16	14	12	....	16	14	12	12	....
5	20	18	16	14	12	16	16	14	12	12

NOTE.—In actual designs the column sizes would vary with changes in load and a tabulation might well be made of column dimensions and steel areas for each floor loading given above, but for the purpose of illustrating the method, one set of figures will suffice.

For the purposes of preliminary estimating we can assume that each column base will require the following quantities:

Since the side walls carry no load, the wall footings need only be strong enough to support the first-story walls and they will also serve to prevent frost from working under the floors.

We therefore assume a footing wall, 12 inches thick and 4 feet 0 inches high running around the building between the wall column foundations.

Each story will be assumed to have an 8-inch brick curtain wall, 3 feet 0 inches high, cement sills, and steel sash from sill to spandrel beam of slab above.

The top story will also have a parapet wall 3 feet 0 inches high with cement coping.

Assuming that we have found by previous calculation

TABLE CXIV.—COLUMN FOUNDATIONS

	Concrete (Cubic Yards)	Forms Square (Feet)	Steel (Pounds)	Excavation (Cubic Yards)
5-story wall column	1.2	44	171	4.0
4-story wall column	1.1	44	130	4.0
3-story wall column	1.0	41	90	3.3
2-story wall column	0.7	39	60	3.0
1-story wall column	0.7	39	50	3.0
5-story interior column	3.1	60	294	9.0
4-story interior column	2.3	52	216	7.1
3-story interior column	2.1	44	150	5.5
2-story interior column	0.9	28	96	2.5
1-story interior column	0.7	20	54	1.9

that the prices used are correct for existing markets and local conditions, we may proceed to set up our table of unit prices as follows:

Cost of floor slab for 150-pound live load:

0.65 cubic feet = 0.024 cubic yard concrete @ $16	$0.384
1 square foot forms	0.20
3.27 pounds steel @ $0.05	0.164
Granolithic finish	0.062
Insurance and profit	0.10
Cost per square foot	$0.91

Cost of roof slab:

0.24 cubic yard concrete @ $16	$0.384
Forms	0.20
2.53 pounds steel	0.127
5-ply roof	0.15
Insurance and profit	0.099
Cost per square foot	$0.96

Cost of 5-story interior column:	
9 cubic yards excavation @ $1	$ 9.00
60 square feet fronting forms @ $0.20	12.00
7 cubic yards concrete @ $16	112.00
60 linear feet column forms @ $1.50	90.00
942 pounds steel @ $0.05	47.10
Insurance and profit	35.90
	$306.00
Cost of 1 linear foot of exterior wall:	
0.4 cubic yard excavation @ $1	$ 0.40
0.15 cubic yard fronting concrete @ $16	2.40
8 square feet fronting forms @ $0.20	1.60
18 square feet 8 inch brick wall @ $0.84	15.12
5 linear feet sill @ $1	5.00
1 linear foot coping @ $1.50	1.50
40 square feet windows @ $0.80	32.00
Insurance and profit	7.38
	$65.40
Cost of one 5-story exterior column:	
4 cubic yards excavation @ $1	$ 4.00
416 cubic feet forms @ $0.20	83.20
4.3 cubic yard concrete @ $16	68.80
570 pounds steel @ $0.05	28.50
Insurance and profit	22.50
	$207.00

Now, suppose that the inquirer who asked for the estimate on the mill building wanted to know what a building of the same size, but of reinforced concrete in the construction just discussed, would cost.

NOTE.—We count corner columns as two wall columns each and deduct the wall columns to determine the total length of wall.

Estimate:

1. 38 interior columns @ $306	$ 11,628.00
2. 50 exterior columns @ $207	10,350.00
3. 853 linear feet outside walls @ $65.40	55,786.20
4. 10,320 square feet 8-inch brick inside walls @ $0.84	8,668.80

5.	24,000 square feet concrete first floor @ $0.28	6,720.00
6.	96,000 square feet reinforced floors @ $0.91	87,360.00
7.	24,000 square feet reinforced roof @ $0.96	23,040.00
8.	Painting	10,200.00
9.	Stairs, 8 flights @ $300	2,400.00
10.	Plumbing, as before	6,000.00
11.	Contingencies	22,215.00
	Total	$244,368.00

which equals $2.04 per square foot of floors or 17 cents per cubic foot which is less than the cost of the mill buildings, on the basis of the figures used.

This same method can be carried out for any type of work. A set of figures might easily be made up covering side-walls, floors, partitions and roofs of houses, but it must always be remembered that the figures reached are approximate only and that their value, even for that purpose, depends upon the care with which they are compiled and the correctness of the prices used.

CHAPTER XV

SUMMARY

SECTION I. SUB-BIDS

A diligent study of the preceding chapters should give the student a grasp of all the subjects covered, and with a reasonable amount of practical experience, he should be prepared to do all of the estimating usually required in the office of a general building contractor.

It is true that there are many building contractors who make a practice of taking every item in detail from the plans, even though it is their practice to sub-let a great deal of the work, but it is believed that it is easier and safer to always get reliable sub-bids on every item that will eventually be sub-let.

Of course, in cases of emergency, when no sub-bids are available, the builder must be prepared to estimate many items of sub-contractors' work. Even so, it is well to remember that, no matter how complete his knowledge of the subject may be, the man actually engaged in a particular line has much greater opportunities for keeping up to date than any builder has, both as regards labor and material prices and conditions in the trade. Furthermore, if the sub-bidder is reliable, his figure will stand and relieve the general contractor of any further concern as to its correctness.

On the other hand, if he always deals fairly with all of his sub-bidders, he will find very few occasions when he will not be able to get all the sub-bids he needs.

Needless to say, fairness requires that a sub-bidder, whose figure is used to make up a successful bid, should be awarded the sub-contract without further question and without "dickering."

The practice of "shopping around" after a contract has been awarded, in order to let sub-contracts at lower figures than those of the sub-bidders whose figures were used, is a very pernicious one, besides making the sub-bidders suspicious of all general contractors, encourages them to add large percentages to their figures for the sole purpose of "knocking off" later on.

Thus, a general contractor who is known to be a "shopper" may lose valuable opportunities because all the sub-bids he receives will be so high as to throw his own bid out.

If a contractor must shop around after receiving contracts, then he should estimate every item himself and take his own chances of being able to sub-let for less than his estimate.

The methods to be used in getting sub-bids will vary with the size of the job, location, and local conditions.

When competition for the general contract is fairly open, as in the case of most public buildings, plans will be on exhibition at all of the general contractors' offices and all sub-bidders will have access to them at one office or another.

In such instances it is only necessary to send out postal card requests to the several sub-bidders who are known to be actively interested in the lines of work to be included.

On small jobs, or jobs for which the competition is more restricted, it is usually necessary to invite sub-bids from people with whom the builder usually deals and sometimes to take the plans and specifications to them.

SECTION II. VISITING THE SITE

In the discussion of the cost of excavating, we gave a list of information to be obtained when visiting the site of any work upon which a bid is being made.

In addition to the items mentioned there, be sure to get the local prices on any materials available for use in the work, costs of carting, sub-bids from nearby bidders when

possible, and information as to any local rules or regulations which may have a bearing upon the figures.

Many architects and engineers put clauses in contracts that require the builder to comply with all local regulations, even though not recited in the specifications.

Such a clause as this might make the sidewalk-protection, or even the working staging, cost twice as much as would otherwise be figured; it might make it necessary to put an extra coat of paint on the steel-work, or an extra coat of plaster on the walls and ceilings, or do a lot of expensive fire-stopping that had not been considered at all.

There are also rules regarding the use of streets and alley-ways that may affect costs and, in times of labor shortages, the fact that another large operation is going on nearby may cause labor costs to mount high, either through increased wages or decreased production.

The availability of and rates at suitable boarding places will also affect the readiness of men to go to a given location, and it may be necessary at times to provide quarters and commissary for them. It is a very rare occurrence when a job commissary pays its own cost, so the loss on the commissary must be figured as part of the cost of doing the work.

SECTION III. MAKING UP THE ESTIMATE

The number of different forms used for estimating is almost as great as the number of contractors who make estimates. Some use stock forms, some use specially ruled and printed forms, some use loose sheets and some use books.

Some contractors combine the unit labor and material prices before multiplying by the quantity, but I prefer to keep a separate column of labor costs and one of material costs.

One construction company, with which I was associated for a time, used a book made up of quadrille-ruled sheets

vith a dollars-and-cents column at the right and left hand ides of each page, one book of about thirty pages being ised for each estimate.

The "take-off" or survey of quantities was made in the niddle of the page and extended to totals for each subject. After calculating the unit labor and material prices for ach item, the extension of the labor-cost was made into he left hand column, and that of the material cost was nade into the right hand column, all the prices on each ide which made up any sub-head of the estimate were hen added up, a double blue-pencil line ruled under each otal, and it transcribed onto the summary page.

The summary might appear something like this:

Name of Job
Location
Architect or Engineer *Date*

Labor		Materials
1,500.00	Preliminaries (page 3)	$ 500.00
1,925.00	Excavation and grading (page 5)	.....
2,750.00	Concrete and forms (page 9)	3,950.00
5,675.00	Brickwork (page 12)	9,250.00
.....	Plastering (sub-bid), (page 13)	5,500.00
1,800.00	Rough carpentry (page 15)	3,650.00
2,230.00	Finish carpentry (page 17)	4,575.00
.....	Roofing and sheet-metal work (sub-bid) 18	1,550.00
.....	Plumbing (sub-bid) 19	2,500.00
.....	Heating (sub-bid) 20	5,000.00
.....	Wiring (sub-bid) 21	900.00
.....	Allowances	500.00
5,880.00		$37,875.00

Total labor	$15,880.00
Materials	37,875.00
	$53,755.00
10 per cent profit	5,375.00
Bid	$59,130.00

Such a method has the advantage of not carrying a running total, from page to page, and it is thus possible to make changes or corrections in any page without having to erase the total on all of them.

As a check, to be sure that all sub-totals are carried into the summary, all the blue-underlined figures should be added together directly from the individual sheets to see that they equal the total in the summary.

It has been found helpful to recapitulate all totals thus

1. Preliminaries	$ 2,000.00	3.7 per cent
2. Direct labor	14,380.00	26.7 per cent
3. Materials	21,425.00	40.0 per cent
4. Sub-bids	15,450.00	28.7 per cent
5. Allowances	500.00	0.9 per cent
	$53,755.00	100.0 per cent

This recapitulation affords an opportunity to compare the relation which the various portions of the present estimate bear to previous estimates and sometimes to show up a difference that might otherwise be overlooked.

It is also helpful in cases of very sharp competition where the bidder might want to figure a smaller percentage of profit on such certain items as sub-bids and allowances, but to retain the full percentage on such items as labor.

In making up the estimate, when a sub-bid is used, it is customary to write in the name of the sub-bidder, to

gether with any pertinent information, on one of the pages of the estimate, and then carry the figure into the summary in the same manner as any other figure but to make a notation as indicated.

If you do not care to use a specially ruled form, ordinary journal paper, which has two sets of dollars-and-cents columns on the right hand side, can be used just as well, one column being used for labor items and the other for materials and sub-bids.

SECTION IV. REMINDER LIST

Some contractors use a reminder sheet, containing a list of items usually entering into the construction of buildings such as the one included here, and the estimator may check off the item as he figures it.

These reminder lists are helpful, but they have the disadvantage that it is practically impossible to prepare one that will be complete, and also that an estimator might depend too much upon the list and neglect to scan the plans and specifications carefully for little notes and inconspicuous clauses.

Items Usually Entering Into the Construction of Buildings

Preliminaries

Bond
Engineers and batters
Entrance for water
Entrance for gas
Entrance for sewer
Insurance
Office building
Protect work
Removing rubbish
Superintendent
Sheds, store house, etc.
Staging for all trades
Temporary doors and screens
Temporary heat for plaster and finish
Temporary sidewalks, fences and lights
Timekeeper
Water for all trades
Watchman
Water boy
Rental of equipment

No. 1—Excavation

Blasting
Cesspools and manholes
Curbing and sidewalks
Drains and dry wells
Excavation
Finished Grading
Piles and excavation fo
same
Pumping
Sheet piling and shoring
Removing loam

No. 2—Foundations

Asphalt or tar, coating outside
Areas
Block granite
Brick walls and piers
Boiler foundations
Concrete footings
Concrete walls
Cement plaster
Engine foundations
Forms for foundations
Granite footings
Steel for foundations
Rubble walls
Retaining walls
Staging for foundations
Waterproofing

No. 3—Brick Masonry

Brick, arch and moulded
Brick, common
Brick, cutting
Brick, enameled
Brick, face
Brick, fire
Brick, hollow
Brick, paving
Brick, special
Brick, teaming
Brick, or concrete nogging and pointing
Boiler setting
Calking windows
Cleaning down masonry wal
Flue lining
Fireplaces
Fire stopping
Mason cutting and jobbing
Oiling brick walls
Terra cotta floors and part
tions
Waterproofing
Wall ties

No. 4—Cut Stone, Etc.

Ashlar and setting
Anchors for stone work
Anchors for terra cotta
Bluestone and setting
Composite stone and setting
Cut granite and setting
Flashings
Granolithic base and steps
Limestone and setting
Miscellaneous trimming stone
Terra cotta trimming setting
Wall coping
Waterproof paint

No. 5—Plastering

Corner beads (metal)
Heat
Iron furring
Plastering wire lath
Plastering wood lath
Plastering brick and terra cotta walls
Plastering concrete ceiling
Plastering two-inch metal partitions
Plastering ornamental
Papier-mache
Metal grounds
Scagliola
Screens

No. 6—Rough Lumber

Bridging
Cutting and jobbing
Centers and lintels
Ceiling framing
Carpet strips
Canvas roofing
Dormers
Furred ceiling
Furred cornices
Furred beams
Furred walls
Furred miscellaneous
Floor framing
Grounds and beads
Lining floors
Miscellaneous framing
Metal wall plugs
Framing of floors
Partitions
Roof framing
Roof boarding
Ratproofing
Setting carpenters' iron
Skylight curbs
Screens
Wall framing, outside
Wall boarding, outside

No. 7—Roofing and Metal Work

Balustrades
Bay windows
Copper roofing
Crestings
Corrugated iron roofing
Cornice brackets
Conductor heads
Conductor footings
Conductor straps
Conductor hooks
Flashings
Gutter and cornice
Gravel strips
Goose necks
Metal sash
Metal ceilings
Metal frames
Ornamental work
Paper
Plastic slate roofing
Roof pans
Rubberoid roofing
Slate roofing
Sidings
Snow guards
Skylights
Tar and gravel roofing
Tile roofing
Tin roofing
Ventilators
Pent house covering
Wire guards for skylights

No. 8—Finish

Belts
Balustrades
Base
Beam casings
Blackboard moulding
Bookcases
Bulkheads
Clapboards
Cornices
Corner boards
Columns, outside
Caps and bases, outside
Chair rail
Columns, inside
Caps and bases, inside
Chalk tray
Closets
Counters
Cupboards
Door trim
Door screens
Dormers and trim
Frieze
Flag pole
Fume closets or hoods
Finish floors
Gutter
Glazed cases
Porch ceilings
Interior windows
Interior doors and frames
Drawers
Hand rail
Interior stairs
Inside blinds
Lattice work
Laboratory tables
Mouldings

Mirrors
Mantels
Outside doors and frames
Outside windows and frames
Outside blinds
Outside pilasters
Porch floors
Pediments
Picture moulding
Pilasters
Paneled ceilings
Pantries
Plate glass
Shirtings
Saddle boards
Steps
Store fronts
Sheathings
Special laboratory fittings
Shelving
Sheet glass
Transoms
Teaming
Water-table
Window trim
Weather strips
Window screens
Wire or other glass
W. C. partitions
W. C. fixtures
Wainscoting

No. 9—Plumbing, Heating, Etc.

Gas piping
Gas connections
Heating
Iron drains
Plumbing
Ventilation
Water connection

No. 10—Steel and Iron

Carpenters' iron
Cornice brackets
Clean-out doors
Cast iron
Fireplace dampers, etc.
Hung ceilings
Iron Stairs
Iron door frames
Masons' iron work
Manhole covers
Metal doors
Metal shutters
Miscellaneous iron
Ornamental iron work erected
Structural iron work erected
Strainers
Shutter hooks
Thimbles
Wire guards

No. 11—Hardware and Nails

Hardware allowance
Hardware for outside doors
Hardware for inside doors
Hardware for w. c. doors
Hardware for lockers
Hardware for cupboards
Hardware for drawers
Hardware for windows
Hardware for transoms
Hardware for hand rail
Hardware for blinds
Hardware for closets
Nails for staging
Nails for framing
Nails for finish
Nails for floor
Floor paper
Sheathing

No. 12

Awnings
Asphalt
Bake oven
Blackboards
Cinder fill
Clean windows
Concrete and granolithic floors
Electric wiring
Engines and dynamos
Electric fixtures
Elevators
Elevator inclosures
Fireproof floors
Fireproof columns
Fireproof girders
Fireproof partitions
Fireproof lintels
Fans
Fireplaces
Filtering plant
Gas
Gas plant
Kitchen fixtures
Laundry machinery
Motors
Marble work
Mail chute
Mosaic floor
Speaking tubes and bells
Switch board
Sweeping system
Slate work
Telephones
Terrazzo floors
Window shades
Tile work

No. 13

Car fares
Freight
Express
Miscellaneous expenses

No. 14

Decorating	Inside painting
Papering	Ornamental picture moulding
Painting iron	Whitewashing
Outside painting	Water color

SECTION V. PRELIMINARIES AND OVERHEAD ITEMS

Among the most difficult items to calculate correctly in a building estimate, are some of the items usually included as overhead or preliminaries.

This is because many of them, such as

Superintendent's salary
Timekeeper's salary
Watchman's salary
Temporary heat and
Commissary loss

are dependent entirely upon the length of time occupied in constructing the building, rather than upon the quantities of materials involved.

In previous chapters the method to be used in calculating the cost of the foreman for a given item of the work has been indicated, practically the same method must be used to figure the total time required to complete the entire structure, making due allowance for the time when two or more parts of the work will proceed concurrently, in order to calculate the salaries of superintendent, timekeeper, clerks and watchman with any degree of accuracy and even then unforeseen delays will often spoil all the calculations.

Such items as office building, sheds, storehouses, sidewalk, bridges and fences, are best figured by making little pencil sketches of them and calculating the labor and materials involved.

If portable office buildings are used, it is only necessary

to figure the transportation; and if standardized sheds are developed the problem will be just that much simpler.

The premium on a surety-bond is always a fixed percentage (usually 1½ per cent) of the total amount of the contract, regardless of whether the indemnity is 25 or 100 per cent of the contract.

Insurance is figured on the payroll, as indicated in previous papers, and the rates vary but are always included in the policies, so that they can readily be determined.

SECTION VI. EQUIPMENT

Even if a builder owns his equipment, it is constantly being worn out or becoming obsolete, so he is entitled to figure into his estimate an amount which would enable him to keep it in repair, to retire his investment or replace his equipment as needed and to make a reasonable profit on his investment.

Rental rates vary greatly, some contractors figure a flat charge per day or week from the time equipment leaves the storehouse until it returns, others have one rate for active time and another for idle time, but in all cases, transportation both ways should be included.

A typical equipment rental list follows:

Terms of Rental Charges and What Tools Are Supposed to Include.

1. Where prices per week are not inserted they are indefinite and are subject to special agreements.
2. No tools are to be rented for less than one week unless special agreement.
3. Tools and machinery are to be shipped from jobs or storehouses in good repair and complete with parts and fittings ready to run, and are to be returned to other jobs or storehouses in good repair, allowing for reasonable wear and tear. If necessary to buy parts at the job to make the

tools or machinery ready to run, same is to be charged to Owner. (Tool and Maintenance Account.) The jobs to pay the expense of repairs or breakage while on their job.

4. The jobs to pay for transportation both ways.
5. On all contracts, the rental of tools or machinery to commence when they are set up and ready to run, and to continue, until they are taken down or shipped, unless we are notified by the owner's representative that they are no longer needed in which case the rental stops on the day of notification.

   Rental charges on tools and machinery to other than our own jobs to commence when they are taken from storehouses or jobs and to continue until returned, unless otherwise agreed.
6. Stone crushers are to be complete with elevator and screen. Bins for large crushers to be furnished by the job. Portable bins on separate rental. Motive power on separate rental. We are to replace worn-out jaws with new.
7. Steam or air drills to have 15 feet of hose and to be replaced by us when worn out. Drills to be kept in repair at the jobs. Drill steel to be charged to the job and taken back at its market value at the close of the job.
8. Derricks are to be complete with fittings, blocks, and a reasonable amount of guy wire and clips for guy derrick.
9. Hoisting engines are to be shipped complete with fittings and fall lines ready to connect with derrick. Fall lines to be replaced by us when worn out, if used with reasonable care.
10. All pumps to be complete with 16 feet of suction pipe or hose and foot valve and 10 feet of pipe for discharge.

    Diaphragm pumps are to include the suction

Description	Rent per Week	Description	Rent per Week
Derrick 40 feet to 60 feet	$12.00	Independent swingers	5.00
Derrick 60 feet to 90 feet	15.00	Locomotive boilers, 50 horsepower	15.00
Stiff-leg derrick	12.00	Vertical boilers, 18 horsepower	7.00
Hand derrick, small	5.00	Vertical boilers, 20 horsepower	12.00
Hand derrick, large	8.00	Stone crushers, 9 inches by 16 inches	20.00
Breast derrick	2.00	Stone crushers, 24 inches by 13 inches	30.00
Wheel derrick	2.00	Stone crushers, 20 inches by 10 inches	25.00
Four-leg derrick	2.00	Stone crushers, 28 inches by 12 inches	40.00
Gin poles	2.00	Stone crusher bin, portable, 30 ton	6.00
Hoisting engines 3D	18.00	Cement gun	30.00
Hoisting engines 2D	13.00	Blasting battery	2.00
Hoisting engines 1D	8.00	Concrete dump carts	2.00
Skeleton engines 3D	11.00	Clamshell buckets	10.00
Skeleton engines 2D	9.00	Orange peel buckets	10.00
Skeleton engines 1D	5.00	Concrete spouting outfits	

Flat car, 24-inch and 36-inch gauge	2.00	Concrete mixer, ¼ yard	15.00
Koppel car	2.00	Bantam mixer with gas engine	12.00
1½-yard 2-way dump car	3.00	Concrete carts	1.00
4-yard dump car	4.00	Scale box iron	2.00
Dray, 10 ton	10.00	Scale box wood	1.00
Pile driver		Circular saw table	2.00
Steam sheet pile hammer, 4-inch	9.00	Band saw	1.00
Bolt cutting machine	1.00	Buzz planer	1.00
Pipe cutter	1.00	Six-foot swing saw	1.00
Gas cutting machine	6.00	Chain hoists 2 or 3 ton	3.00
Blacksmith kit and forge	1.50	Chain hoists 5 ton	4.00
Riveting kit and forge	1.50	Barrett jacks	1.00
Cableways 1,000 feet	60.00	Screw jacks	.50
Hand-drills, press	.50	Albany jacks	1.00
Rock-drills, tripod	10.00	Norton jacks	1.00
Jack hammer drills	6.00	Bed-screw jacks	.50
Electric boring drills	5.00	One-horse, 2-wheel dump carts	
Ratchet drills	.50	Two-horse, 4-wheel wagons	3.00
Concrete mixer, ⅓ yard	25.00	"Chocolate drop"	10.00
Concrete mixer, ¾ yard	22.00	Quarry bar	10.00
Concrete mixer ½ yard	20.00	Quarry bar, 4-inch, 2½-inch	

Description	Rent per Week	Description	Rent per Week
Elevator platform, small	1.00	Electric motors, 20 horsepower	
Steam sheet pile hammer, 6-inch	$12.00	Electric motors, 40 horsepower	
Timber dollies	.50	Electric motors, 50 horsepower	
Timber truck, 2-wheel	.50	Electric motors, 60 horsepower	
Truck, 4-wheel	2.00	Electric motors, 75 horsepower	
Air compressors, 8 inches by 8 inches	15.00	Engine, vertical, 8	6.00
Air compressors, 22 inches by 13 inches by 16 inches	40.00	Engines, horizontal, 25 horsepower	12.00
		Engines, horizontal, 20 horsepower	10.00
Air compressors, 19 inches by 12 inches by 16 inches	35.00	Engines, horizontal, 40 horsepower	15.00
		Diving suits, complete	24.00
Lights, carbic	1.50	Pump, pulsometer	10.00
Winch	2.50	Pump, diaphragm hand	5.00
Industrial R. R.		Pump, hand	2.00
Electric motors, 5 horsepower		Pump, gasoline 3-inch	8.00
Electric motors, 10 horsepower		Pump, 12-inch discharge, belted	12.00

Pump, 10-inch discharge, belted	10.00	Car unloaders	1.00
Pump, 8-inch discharge, belted	8.00	Sharpening machine	18.00
Pump, 6-inch discharge, belted	6.00	Vises	.50
Pump, 6-inch discharge, D.C.	12.00	Scows, 3 feet by 30 feet by 8 feet	5.00
Pump, 5-inch discharge, D.C.	10.00	Shears, McLane	.50
Pump, 4-inch discharge, D.C.	8.00	Tents, 12 by 14	2.00
Concrete surfacer	8.00	Tents with flies, 12 by 14	3.00
Power grindstone	1.00	Tents, 10 by 10	1.50
Rowell chimney hoist	5.00	Tents with flies, 10 by 10	2.00
Portable houses	3.00	Taps and dies sets	.50
Lead furnace on wheels	2.00	Typewriter	
Staging clamps	.02	Bolt threading machine	.50
Putlogs Patent	.04	Leveling instrument	1.00
Plow, root, six-horse	4.00	Motor truck, 5-ton	
Plow, root, four-horse	3.00	Motor truck, 4-ton	
Punch, hand-screw	1.00	Motor truck, 3-ton	
Rod bender	1.00	Motor truck, 1½-ton	
Ram, hydraulic	1.00	Concrete bucket, ¾-yard	2.00
Roofer's kit	5.00	Concrete bucket, 1-yard	2.00
Drag scrapers	.50	Concrete bucket, 1½-yard	3.00
Drag scrapers, two-wheel	2.00	Concrete bucket, 2-yard	3.00

hose 16 feet long, and to be replaced by us when worn out.

Additional pipe or hose over 16 feet is to be charged to the job, and taken at the close of the job at its market value.

APPENDIX

RECOMMENDED READING

he estimator who would be thoroughly informed as many of the various phases of his profession will do , in addition to persistently collecting all available ex- ence data, to obtain as many of the following books as ible and familiarize himself with their contents.

BERT P. GILLETTE, "Handbook of Cost Data," McGraw- ill Book Co., New York.

BERT P. GILLETTE, "Handbook of Construction Cost," IcGraw-Hill Book Co., New York.

BERT P. GILLETTE, "Rock Excavation, Methods and ost," McGraw-Hill Book Co., New York.

BERT P. GILLETTE, "Handbook of Construction Equip- ent," McGraw-Hill Book Co., New York.

BERT P. GILLETTE, "Earthwork and Its Cost," McGraw- ill Book Co., New York.

LETTE AND DANA, "Cost-Keeping and Management En- neering," McGraw-Hill Book Co., New York.

LETTE AND HILL, "Concrete Construction, Method and ost," McGraw-Hill Book Co., New York.

LOR AND THOMPSON, "Concrete Costs," John Wiley & ons, New York.

NK R. WALKER, "The Building Estimators' Reference ook," Frank R. Walker, Chicago.

LLIAM ARTHUR, "New Building Estimators' Handbook," . P. C. Book Co., New York.

L AND JOHNSON, "Handbook of Building Construction," IcGraw-Hill Book Co., New York.

MON BRICK MFRS. ASSOC'N, "Brick, How to Build and ow to Estimate," Chicago.

Morris Knowles, "Industrial Housing," McGraw-Hill Book Co., New York.

John C. Trautwine, "Civil Engineers' Pocket-book," John C. Trautwine, Philadelphia.

also

Engineering News-Record (New York), weekly.
Engineering and Contracting (Chicago), weekly.
Concrete (Detroit), monthly.
Contract Record (Toronto).

Each of the periodicals mentioned frequently carries very helpful articles on methods and costs of doing many kinds of construction work.

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